GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: July 14, 1978

Project Title: Test and Evalution Laboratory for Millimeter Beamrider Applications

Project No: A-2166

Project Director: Mr. R.G. Shackelford

Sponsor: U. S. Army Missile R&D Command; ATTN: DRDMI-ICBD; Restone Arsenal, AL 35809

Agreement Period: From 6/19/78 Until 2/19/80 ~~10/18/79~~

Type Agreement: Contract No. DAAK40-78-C-0158

Amount: $432,841 (Incrementally funded @ $40,000 thru approx. 10/18/78)

Reports Required: Monthly Tech. Progress Letter; Monthly Cost & Performance Reports; Final Technical Report

Sponsor Contact Person (s):

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(thru GTRI)

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Defense Priority Rating: DO-A2 under DMS Reg. 1

Assigned to: Electromagnetics Laboratory (School/Laboratory)

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CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date October 3, 1983

Project Title: Test and Evaluation Laboratory for Millimeter Beamrider Applications

Project No: A-2166

Project Director: Mr. R. G. Shackelford

Sponsor: U. S. Army Missile R&D Command

Effective Termination Date: 4/29/81

Clearance of Accounting Charges: 4/29/81

Grant/Contract Closeout Actions Remaining:

- [X] Final Invoice and Closing Documents
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other _____

Assigned to: EML (School/Laboratory)

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FORM OCA 10:781

A-2166

A REVIEW OF THE DESIGN STATUS OF UNITS 1 AND 2 OF THE MILLIMETER GUIDANCE TECHNOLOGY HARDWARE SYSTEM

Contract DAAK40-78-0-0158
(A-2166)

Robert W. McMillan
Michael J. Sinclair
Robert G. Shackelford

19 October 1978

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

A REVIEW OF THE DESIGN STATUS OF UNITS 1 AND 2 OF THE MILLIMETER GUIDANCE TECHNOLOGY HARDWARE SYSTEM

1.0 BACKGROUND/PURPOSE OF THE MILLIMETER LABORATORY

A design review for the Millimeter Guidance Technology Hardware was held at MIRADCOM on Thursday 5 October, 1978. During this review, a brief overview of the purpose of the hardware, together with a short discussion of the functions of the five subsystems which make up the total system, was presented. Preliminary designs for the 94 GHz coherent system and the 140 GHz incoherent system were then discussed, and several suggestions from MIRADCOM and Georgia Tech personnel were noted with the intent of incorporating them into the final design.

2.0 94 GHz SYSTEM

The 94 GHz coherent transmitter/receiver was discussed first. This system uses a pulsed extended interaction oscillator (EIO) transmitter that will be both phase and injection locked to a standard source. The receiver is a Schottky barrier mixer using a gallium arsenide diode in a tunable Sharpless wafer mount. The receiver local oscillator is a 93.25 GHz phase locked Gunn oscillator with a power output of 10 mW which will also serve as master oscillator for the entire system. The performance specifications of the 94 GHz system are given in Table I.

Figure 1 is a simplified block diagram of this system. The 94 GHz phase locked Gunn oscillator serves as a reference source both for phase locking the injection locking klystron which in turn injection locks the EIO, and for phase locking the EIO directly. This source also serves as the receiver local oscillator. The output of the receiver second detector feeds a microprocessor based data processing system which provides for both on-line and post detection data reduction.

SIMPLIFIED BLOCK DIAGRAM OF 94 GHz SYSTEM

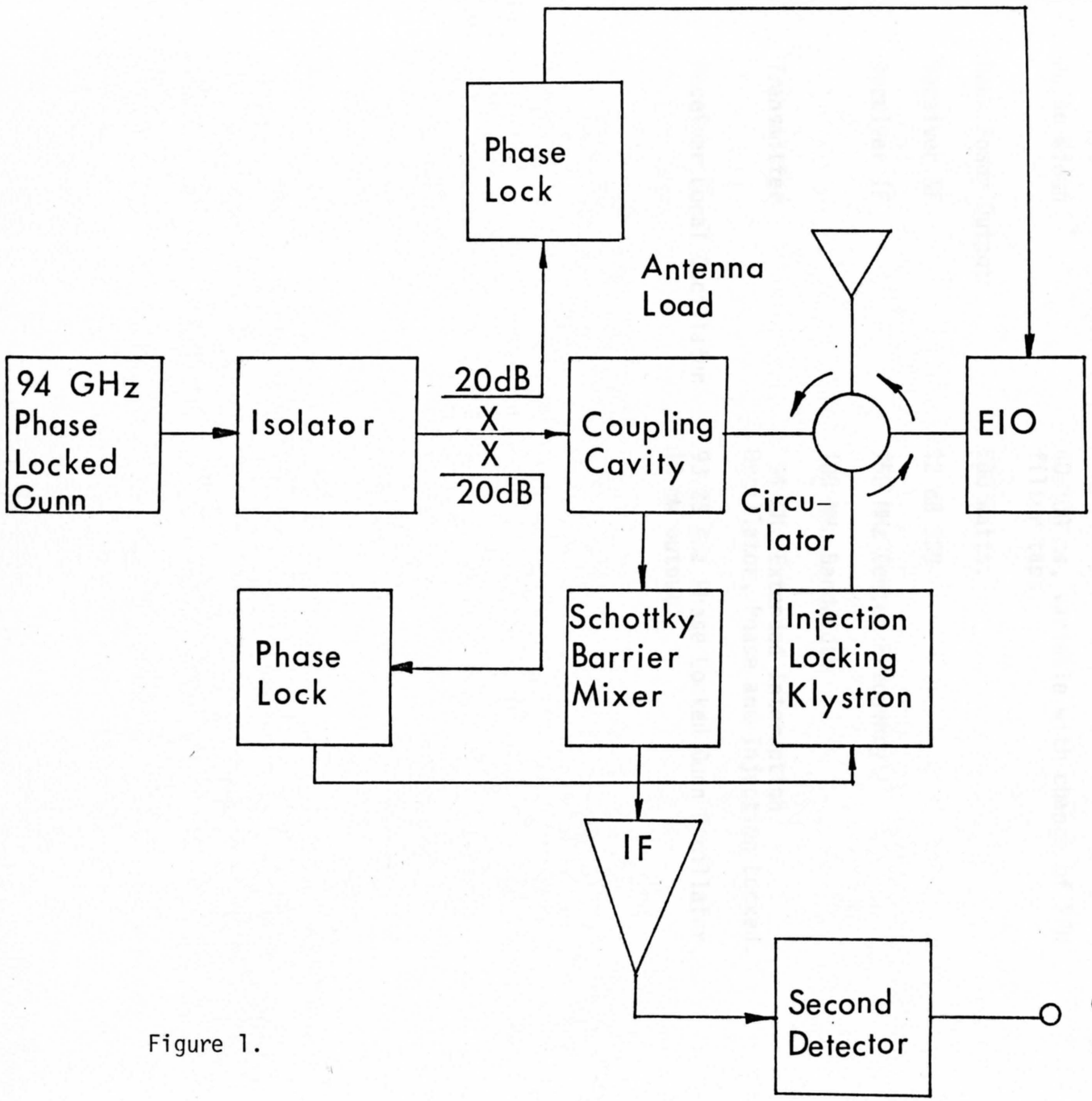


Figure 1.

TABLE I

PERFORMANCE SPECIFICATIONS FOR THE 94 GHz SYSTEM

Frequency	94 GHz Atmospheric Window (94.0 GHz)
PRF	10-200 Hz Required, 10-1000 Hz Obtainable or Externally triggered from Antenna Scan.
Pulse Width	40-100 ns, variable with change of PFN filter taps.
Peak Power Output	500 Watts.
Receiver NF	12 dB SSB
Receiver IF	750 MHz Center Frequency
	100 MHz Bandwidth
Transmitter	94 GHz Extended Interaction Oscillator, Phase and Injection Locked.
Receiver Local Oscillator	93.25 GHz Phase Locked Gunn Oscillator, 10 mW output.

2.1 94 GHz Transmitter

A more detailed block diagram of the transmitter is shown in Figure 2. The EIO modulator and power supply will be built at Georgia Tech and will be discussed later in more detail. The EIO cooling system will be a commercial temperature controlled heat exchanger. The E-H tuners are included for precise phase control which will hopefully limit the amount of transmitter and injection locking power incident on the receiver. Otherwise, it may be necessary to use waveguide switches or other means to limit this power. Both phase lock systems will be virtually identical to a system first built by P. S. Henry* of Bell Laboratories, and discussed in greater detail in the next paragraph. An isolator is used on the output of the injection locking klystron to minimize frequency pulling due to the unmatched load which the EIO may present. The power supply for this klystron is a commercial type built by Micro-Now Instruments, and the cooling system is a recirculating heat exchanger type built at Georgia Tech.

The phase lock system to be used for both the EIO and klystron is shown in Figure 3. The operation of this circuit, which has a frequency control loop for large corrections in addition to the phase control loop, may be understood by considering the following discussion. Part of the 94 GHz Gunn oscillator output is picked off and mixed with the output of the injection locking klystron to generate an intermediate frequency of 750 MHz. This IF power is split into equal parts and compared to the output of a 750 MHz crystal-controlled reference oscillator in both in-phase and quadrature modes. If the klystron is locked, the output of the in-phase detector will be a slowly varying dc correction voltage which is coupled via dc amplifiers to the klystron reflector. The output of the quadrature detector in this case is also a dc level which is blocked by the capacitor so that its output has no influence on the frequency of the klystron. Now assume that the klystron is unlocked. The output of both the in-phase and quadrature detectors will

*P. S. Henry, "Frequency Agile Millimeter-Wave Phase Lock System", Rev. Sci. Instrum., 47, 9, Sept. 1976, pp. 1020-1025.

BLOCK DIAGRAM OF 94 GHz TRANSMITTER

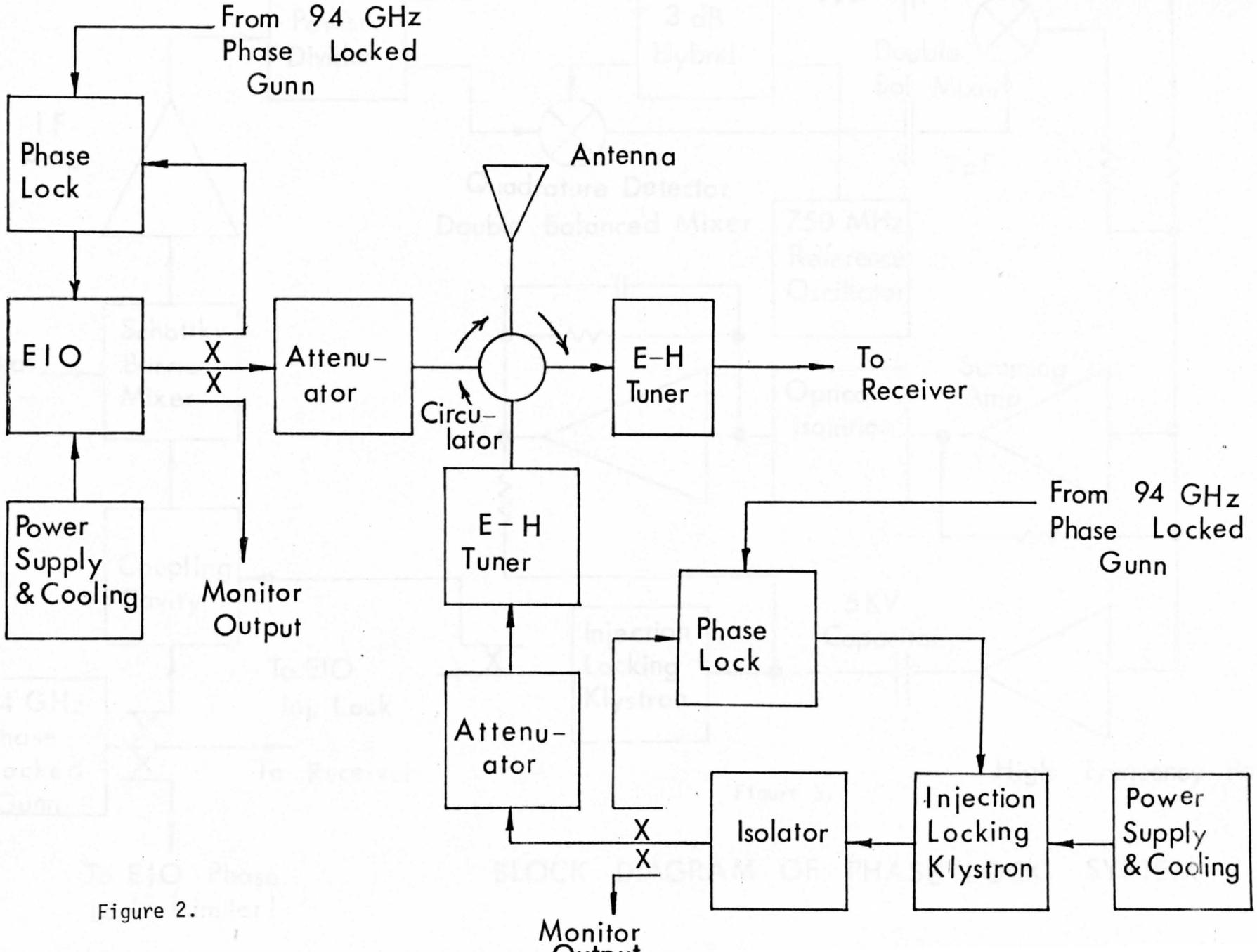


Figure 2.

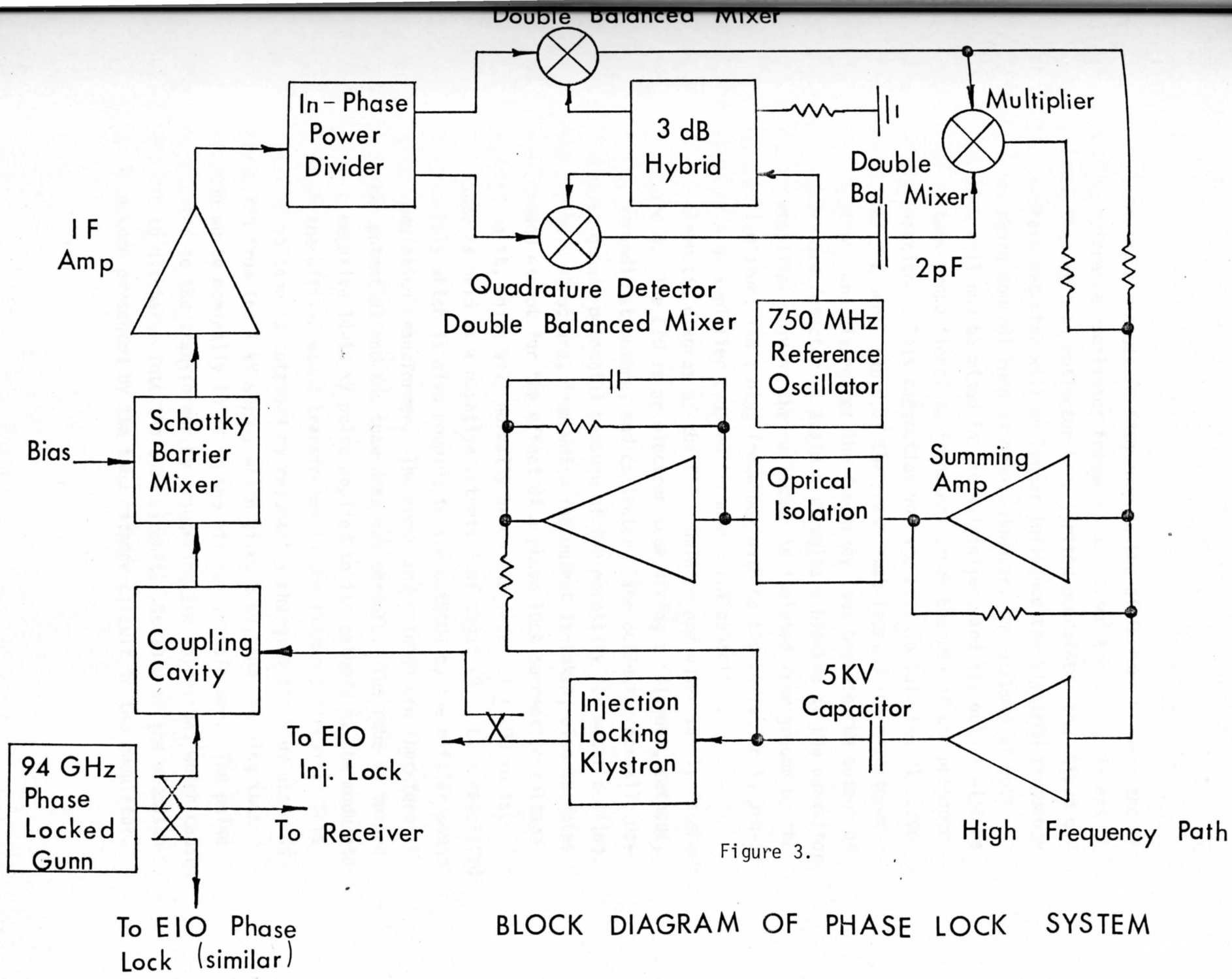


Figure 3.

BLOCK DIAGRAM OF PHASE LOCK SYSTEM

now be ac signals equal in frequency to the difference between the IF and the reference oscillator frequencies. Since the dc amplifiers driving the klystron reflector have limited bandwidth, the output of the in-phase detector will no longer influence the klystron frequency and the phase control loop is open. However, the outputs of both detectors will now be mixed in the multiplier, and its output will be a dc voltage proportional to frequency error because of the presence of the capacitor. This correction voltage acts to pull the klystron within the frequency range of the phase lock loop, which recaptures the klystron, and disengages the frequency loop because the output of the quadrature detector is again a dc voltage blocked by the capacitor. The dc amplifier driving the reflector is isolated from ground by the optical isolator, and a high frequency path to the reflector is provided by a dc amplifier coupled through a 5KV capacitor.

A schematic diagram of the EIO modulator and power supply is shown in Figure 4. The EIO is an electron tube having a filament, cathode, anode, periodic structure, and collector. The collector normally operates at ground potential because of the necessity for water cooling. The periodic structure, from which the output is taken, also operates near ground except for the effect of a phase lock correction voltage applied to it, which will normally be on the order of $\pm$ 100 volts. The anode is held at a negative potential of about -8 kV by a regulated power supply which is also coupled to the cathode by the bifilar wound pulse modulation transformer. The anode and cathode are therefore at the same potential and the tube does not conduct. The tube is turned on by a negative 14-16 kV pulse applied to its cathode by the modulator through the bifilar wound transformer in the filament circuit. This level of voltage is obtained by resonantly charging the Blumlein modulator PFN from the 4 kV supply which gives 8 kV, and stepping this voltage up to nominally 16 kV in the bifilar transformer. The pulse is applied to the transformer by triggering the thyratron, which causes the PFN to discharge into the tube circuit. Because of the mismatch in impedance presented by the tube cathode circuit to the modulator,

E I O SHOWN WITH POWER SUPPLY AND MODULATOR CIRCUITS

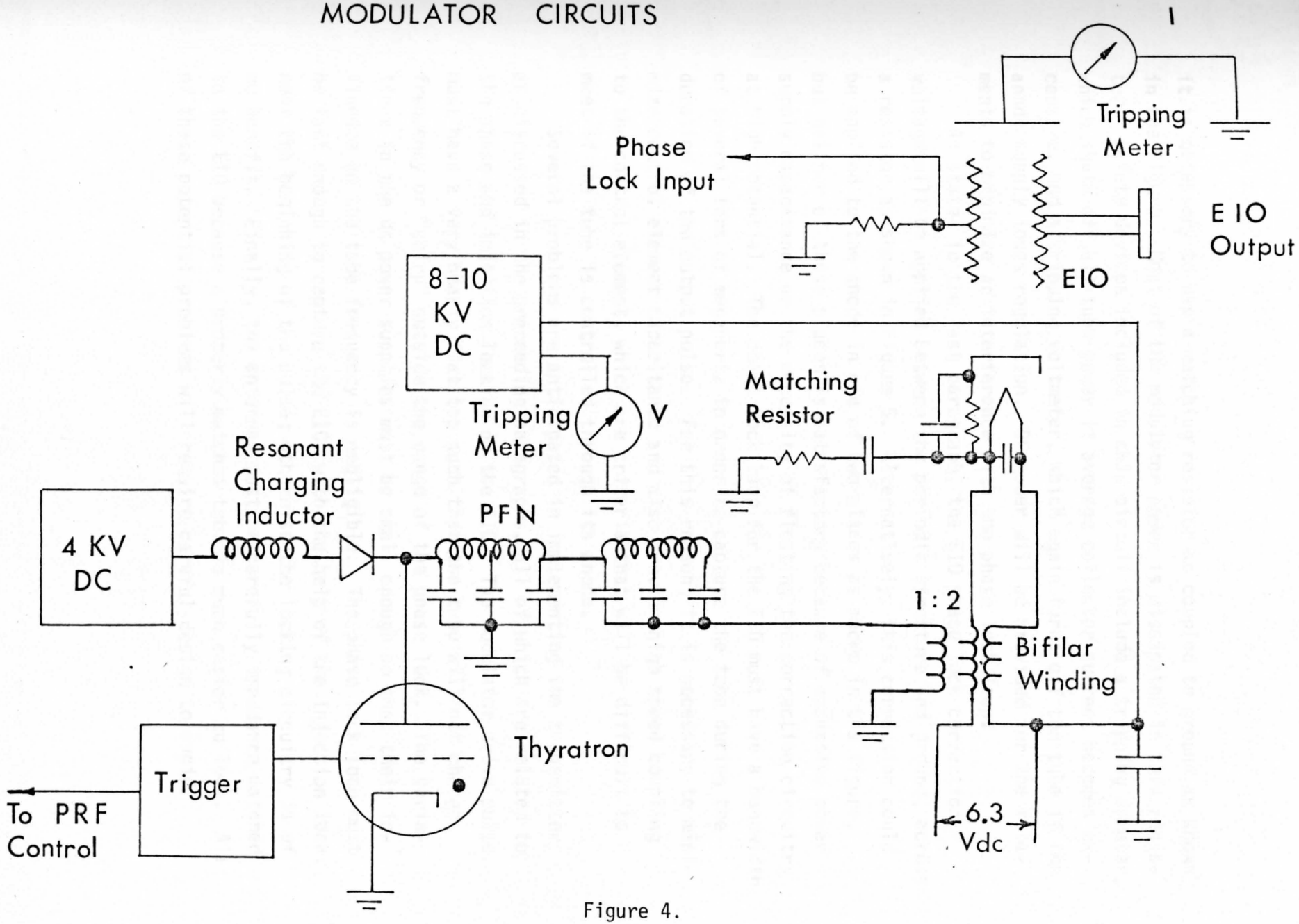


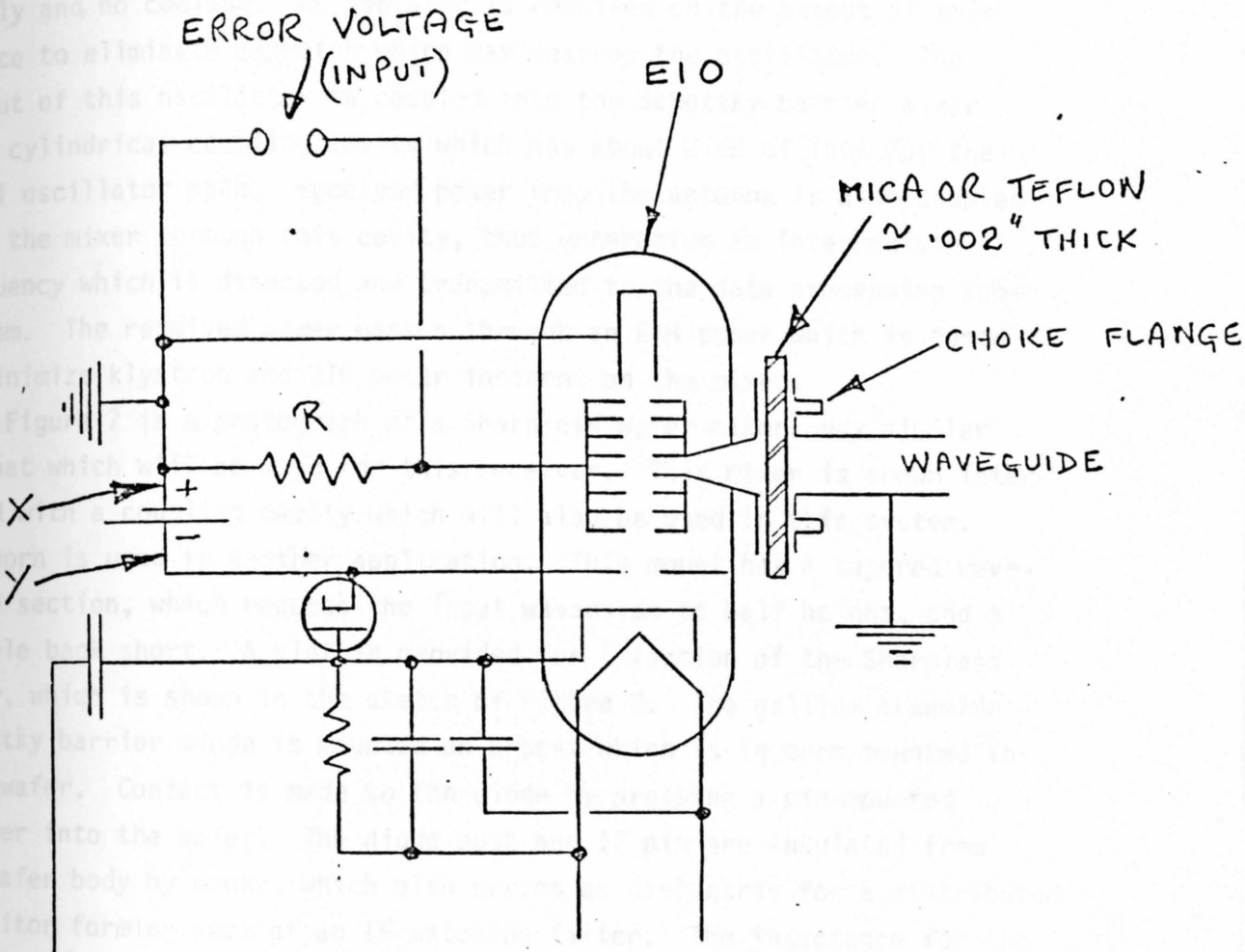
Figure 4.

it is necessary to use a matching resistor ac coupled to ground as shown in the Figure. Most of the modulator power is dissipated in this resistor. Safety devices included in this circuit include a tripping ammeter, which shuts off all tube power if average collector current becomes excessive, and a tripping voltmeter, which again turns off the tube if the anode supply loses regulation. DC power will be provided for the filaments to minimize ac interference with the phase lock loop.

As stated in the last paragraph, the EIO phase lock correction voltage will be applied between the periodic structure and ground, across a resistor as shown in Figure 5. Alternatively, this correction could be applied to the anode in one of two places as shown in the figure, but neither of these places is satisfactory because of excessive power supply capacitance or the necessity of floating the correction circuitry at high potential. The phase lock loop for the EIO must have a bandwidth of several tens of megahertz in order to capture the tube during the duration of the output pulse. For this reason, it is necessary to minimize control element capacitance and also provide high speed coupling to the control element, which are criteria that will be difficult to meet if the tube is controlled through its anode.

Several problems are anticipated in implementing the transmitter as discussed in the preceeding paragraphs, all of which are related to the phase and injection locking of the EIO. The modulator drive pulse must have a very nearly flat top such that the tube will not change frequency or "chirp" outside the range of the phase lock. The variations in the dc power supplies must be small enough so that their influence on the tube frequency is negligible. The phase lock loop must be fast enough to capture the EIO, with the help of the injection lock, near the beginning of the pulse; otherwise the locking circuitry is of no benefit. Finally, the antennas must be carefully impedance matched to the EIO because a properly matched tube is much easier to lock. All of these potential problems will require careful design to avoid.

Specification: ELECTRONIC FREQUENCY CONTROL



ERROR SIGNAL CAN BE INJECTED AS SHOWN (KEEP "R" SMALL ≪ 10KΩ)
OR:-
AT X (WATCH CAPACITY OF POWER SUPPLY ETC. TO GND.)
OR:-
AT Y (HIGH VOLTAGE PROBLEMS)

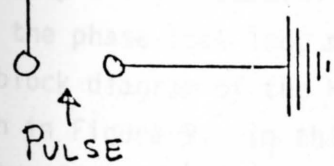


Figure 5.

2.2 94 GHz Receiver System

A block diagram of the 94 GHz receiver is shown in Figure 6. The phase locked Gunn local oscillator requires only a low voltage dc supply and no cooling. An isolator is required on the output of this device to eliminate mismatch which may destroy the oscillator. The output of this oscillator is coupled into the Schottky barrier mixer by a cylindrical coupling cavity which has about 2 dB of loss for the local oscillator path. Received power from the antenna is also coupled into the mixer through this cavity, thus generating an intermediate frequency which is detected and transmitted to the data processing subsystem. The received power passes through an E-H tuner which is tuned to minimize klystron and EIO power incident on the mixer.

Figure 7 is a photograph of a Sharpless wafer mixer body similar to that which will be used for this receiver. This mixer is shown interfaced with a coupling cavity which will also be used in this system. The horn is used in another application. This mount has a tapered waveguide section, which reduces the input waveguide to half height, and a tunable back short. A slot is provided for insertion of the Sharpless wafer, which is shown in the sketch of Figure 8. The gallium arsenide Schottky barrier diode is mounted on a post which is in turn mounted in this wafer. Contact is made to the diode by pressing a pin-mounted whisker into the wafer. The diode post and IF pin are insulated from the wafer body by epoxy, which also serves as dielectric for a distributed capacitor forming part of an IF matching filter. The inductance for the filter is due to the pins themselves. The IF pin contacts the connector in the mixer body which is the IF output. This type mixer has been successfully used on several programs at Georgia Tech, and will also be used in the phase lock loop mixer applications for this program.

A block diagram of the Hughes 94 GHz phase locked Gunn oscillator is shown in Figure 9. In this device, an internal reference crystal oscillator is used to phase lock a power oscillator oscillating at a higher frequency. A harmonic of this oscillator is mixed with the 94 GHz

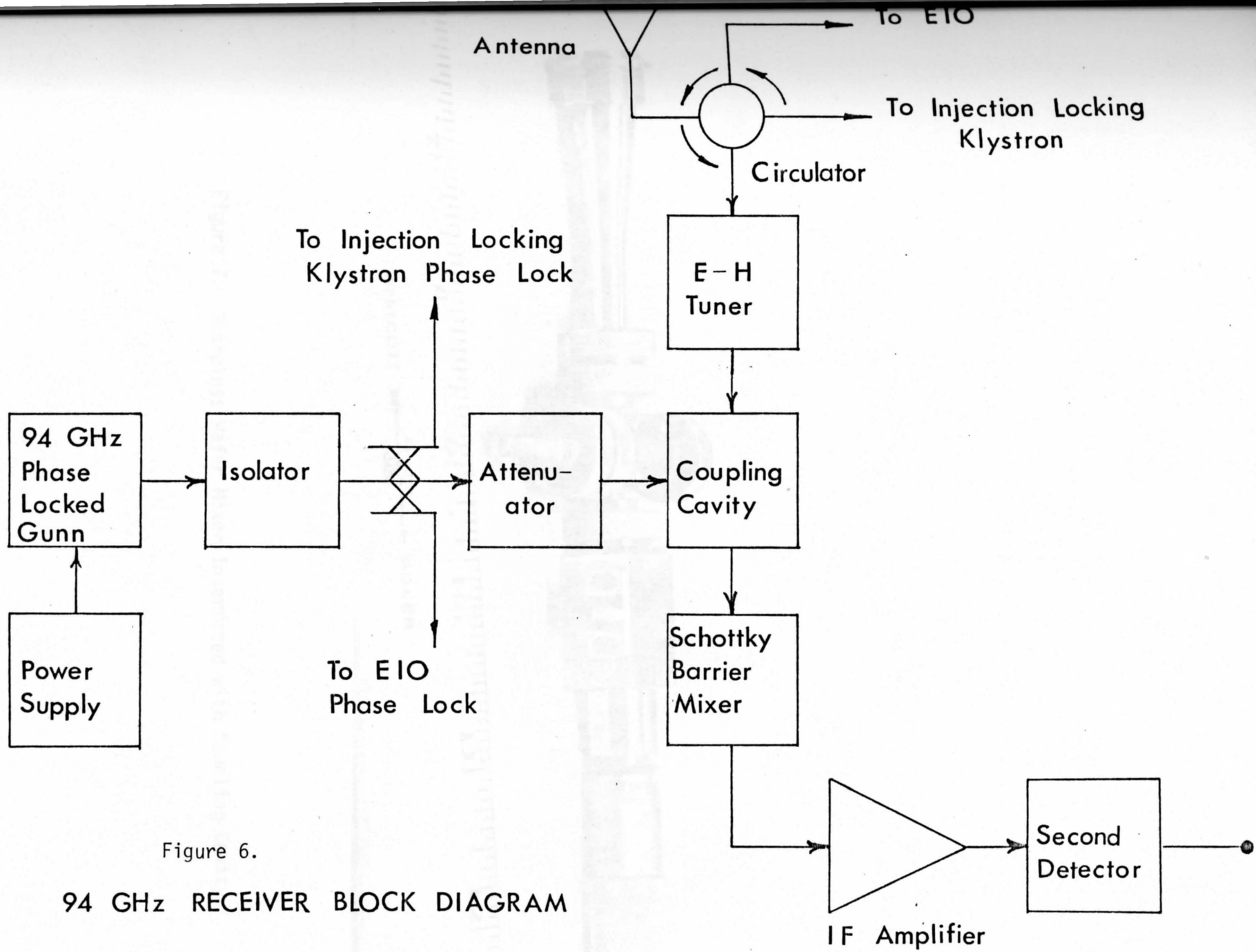


Figure 6.

94 GHz RECEIVER BLOCK DIAGRAM

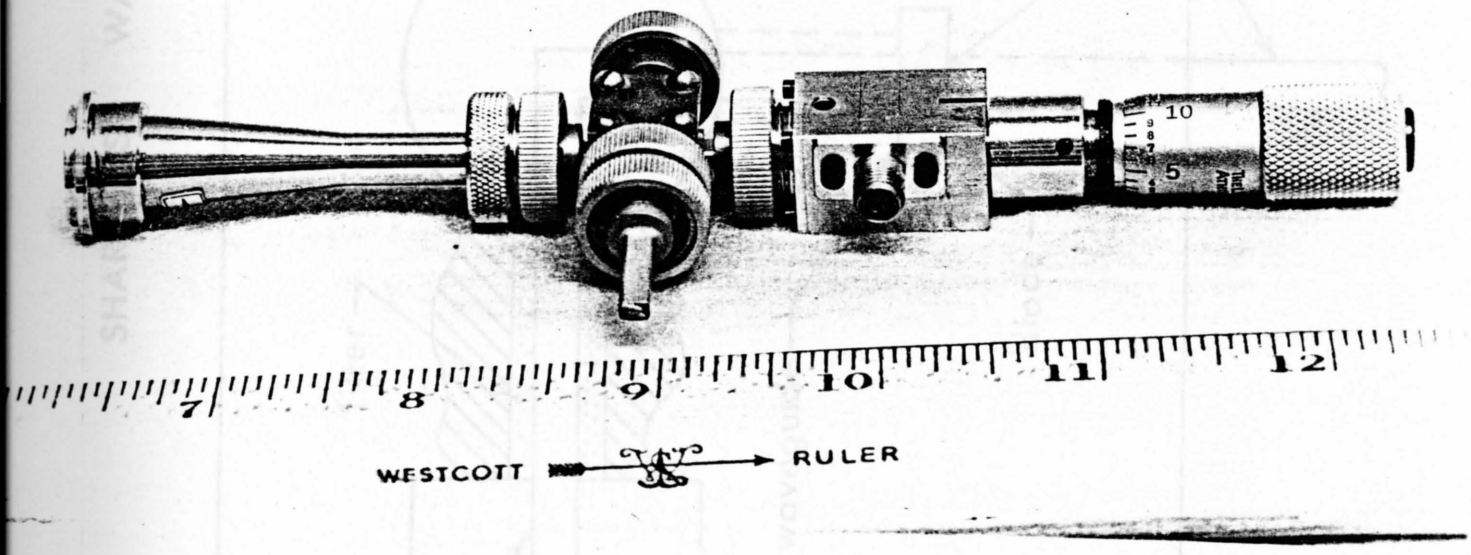


Figure 7. Sharpless Wafer Mixer Interfaced with Coupling Cavity.

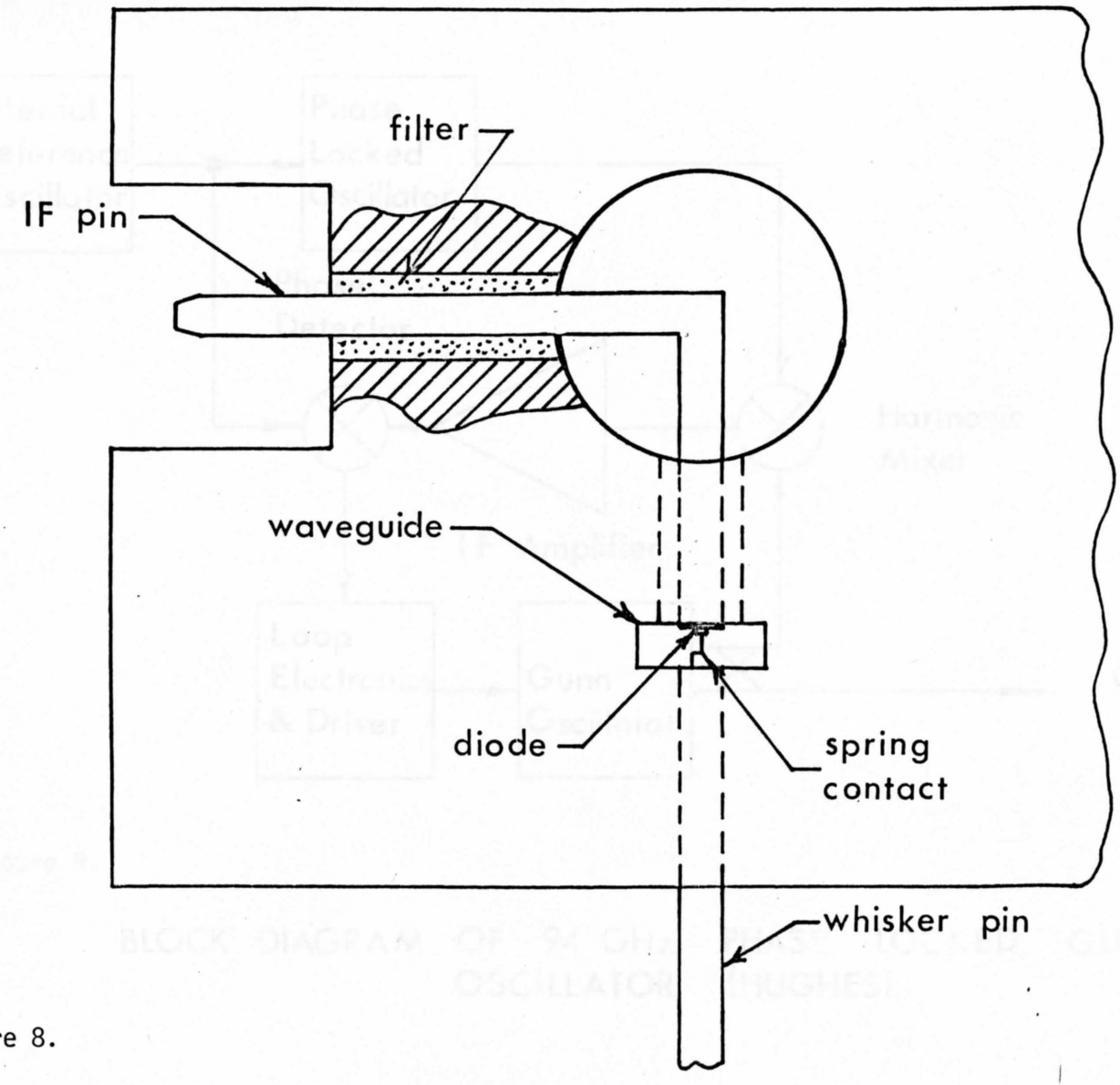


Figure 8.

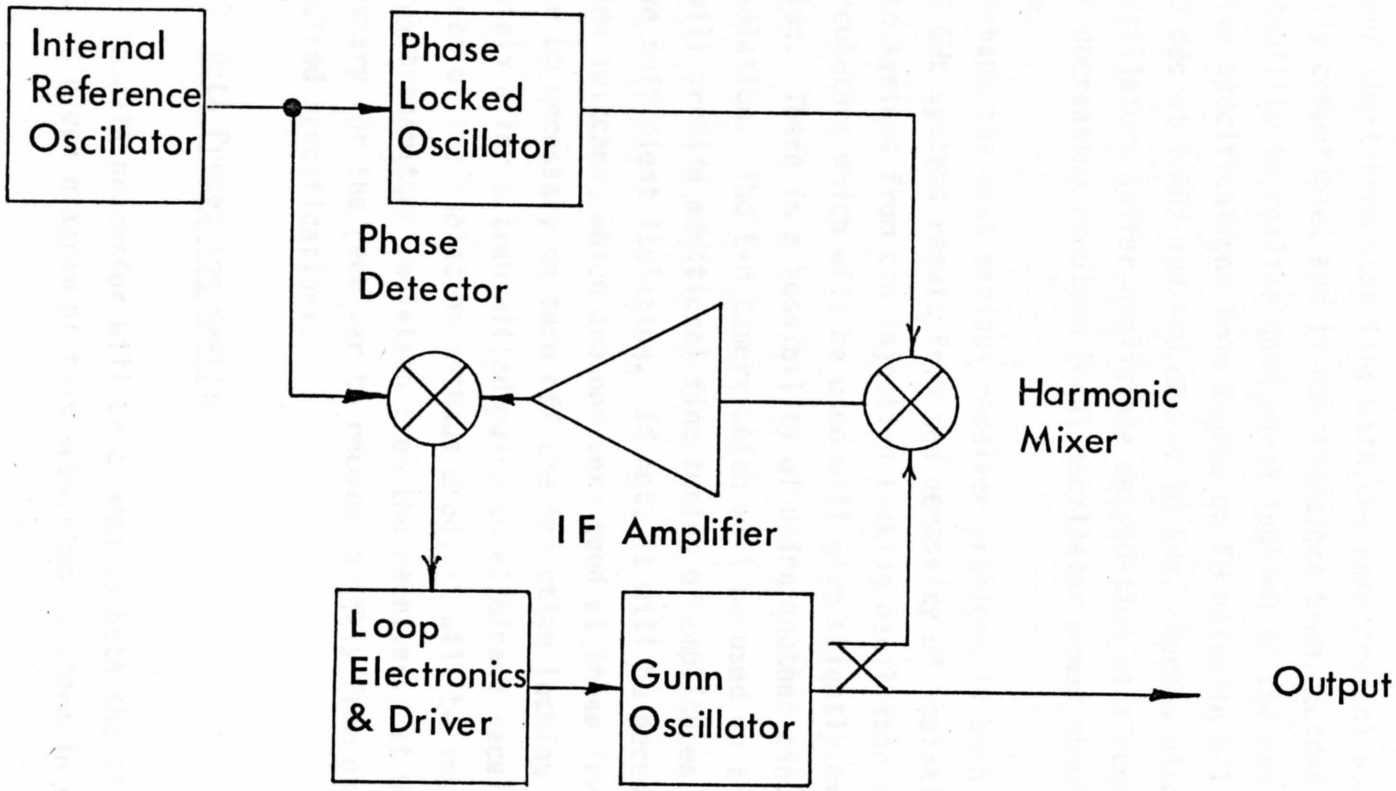


Figure 9.

BLOCK DIAGRAM OF 94 GHz PHASE LOCKED GUNN OSCILLATOR (HUGHES)

Gunn oscillator output to generate an intermediate frequency equal to the reference oscillator frequency. This IF is compared in phase to the reference oscillator and a correction voltage for the Gunn oscillator phase lock is generated. To realize a good source to which the EIO and klystron may be locked, it is necessary that the Gunn oscillator have good short-term stability. Hughes Aircraft has advised that both long- and short-term stability with the same crystal oscillator are not generally compatible, and it has therefore been decided to choose short term stability to realize good phase locking in the rest of the system. Tentative specifications from Hughes on FM noise in a 1 Hz bandwidth are -60 dBc at 1 kHz and -80 dBc at 10 kHz. Hughes also states that Gunn oscillators suffer negligible degradation as a function of time, so that decreasing receiver local oscillator power should not be a problem.

Perhaps the most serious receiver problems in both the 94 GHz and the 140 GHz systems result from the necessity of isolating the mixers in these systems from the injection locking oscillator and the EIO. The circulators which will be used will give slightly over 20 dB of isolation. There is a possibility of using another circulator to double this isolation. The E-H tuners which will be used on the circulator ports will provide additional fine tuning of amplitudes and phases and may give sufficient isolation. If not, it will be necessary to use waveguide switches, which are not very good at these frequencies. It may also be necessary to turn off the injection locking klystron immediately after a transmitted pulse to eliminate receiver overdrive. Regardless of the isolation methods used, it will be impossible to keep all stray transmitter radiation from the receiver. It will therefore be necessary for the receiver to recover quickly from overdrive to meet the required specifications.

2.3 Data Processing System

A data processor will be common to both the 94 GHz and 140 GHz systems. A block diagram of this subsystem is shown in Figure 10. Using

this processor, it will be possible to perform statistical analyses of received data including pulse height analysis, normalization, detection probability, and relationships among system parameters. Those results may be displayed in histogram form on an interactive display, read out to an analog recorder, or stored for later use or further processing. It will also be possible to store raw data for later processing. The storage capacity for raw data is five megabytes per data cartridge which will allow about 15 one minute runs at a 2 kHz data rate. Limited only by data rates, real time processing can be effected to monitor system performance. Off line data processing can be done on site as a high level language such as BASIC or FORTRAN will be resident in the machine. The 3M data cartridges are convenient media to transfer data to a larger machine such as a PDP11.

3.0 140 GHz SYSTEM

Figure 11 is a block diagram of the 140 GHz system including both transmitter and receiver. The transmitter is a free-running 140 GHz EIO which is coupled to the antenna by a circulator. The receiver is a Schottky barrier diode mixer in a Sharpless wafer mount, identical to the 94 GHz mixer. Local oscillator power from the 140 GHz klystron is coupled to the mixer by a coupling cavity, as described earlier. The output of the receiver is taken from a second detector. The data processing system may also be used with this transmitter/receiver in the same way as it is used with the 94 GHz system.

Possible problems with the 140 GHz system will probably be limited to the receiver and will be of the same type as discussed for the 94 GHz receiver, namely isolation of the mixer from the transmitter. If the receiver will withstand overdrive without damage and will recover quickly, these problems will be less severe for the 140 GHz system than for the 94 GHz system.

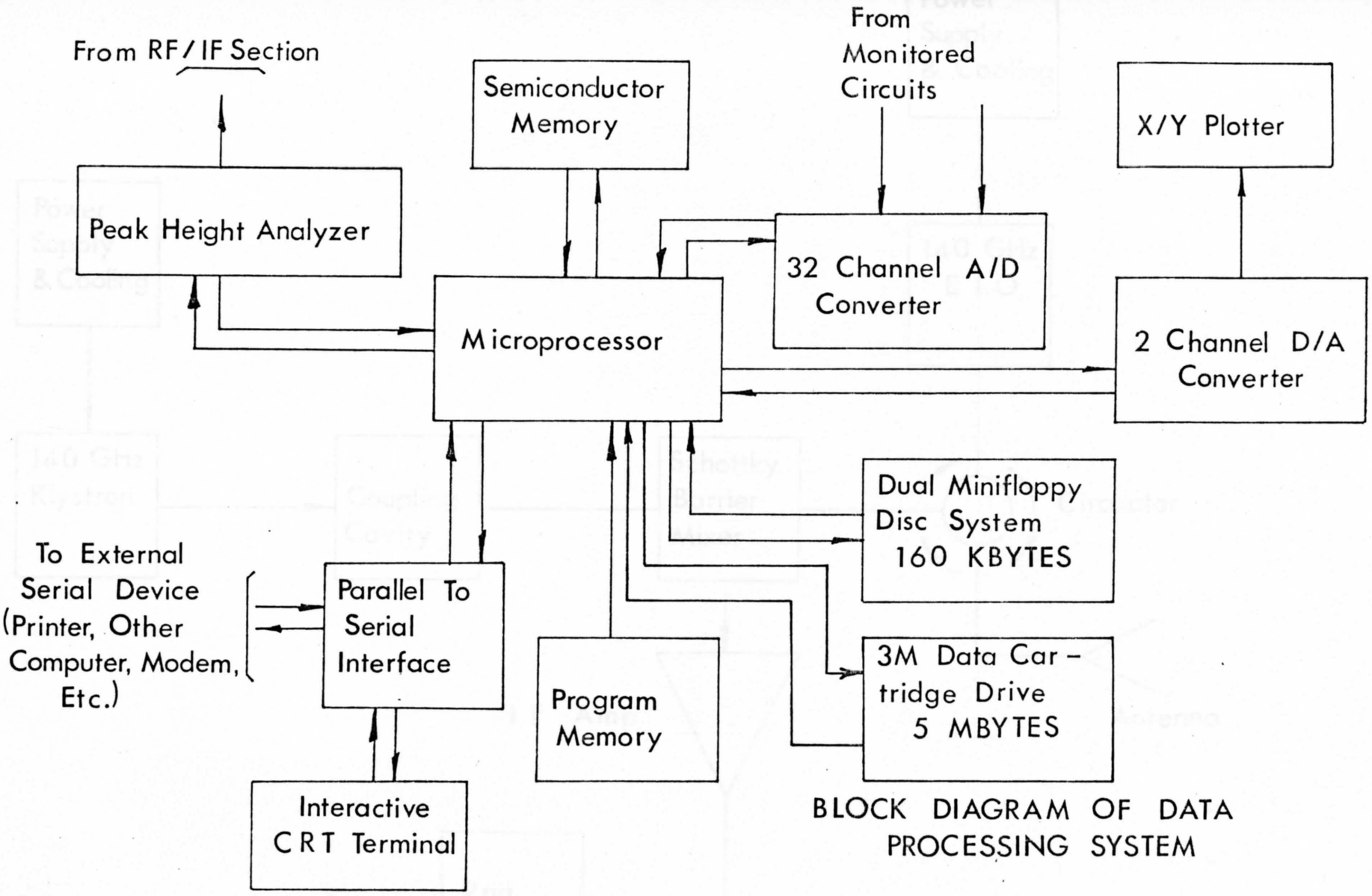

From RF/IF Section
Semiconductor Memory
From Monitored Circuits
X/Y Plotter
Peak Height Analyzer
32 Channel A/D Converter
Microprocessor
2 Channel D/A Converter
Dual Minifloppy Disc System 160 KBYTES
To External Serial Device (Printer, Other Computer, Modem, Etc.)
Parallel To Serial Interface
Program Memory
3M Data Cartridge Drive 5 MBYTES
Interactive CRT Terminal
BLOCK DIAGRAM OF DATA PROCESSING SYSTEM

Figure 10.

BLOCK DIAGRAM OF 140 GHz
TRANSMITTER / RECEIVER SYSTEM

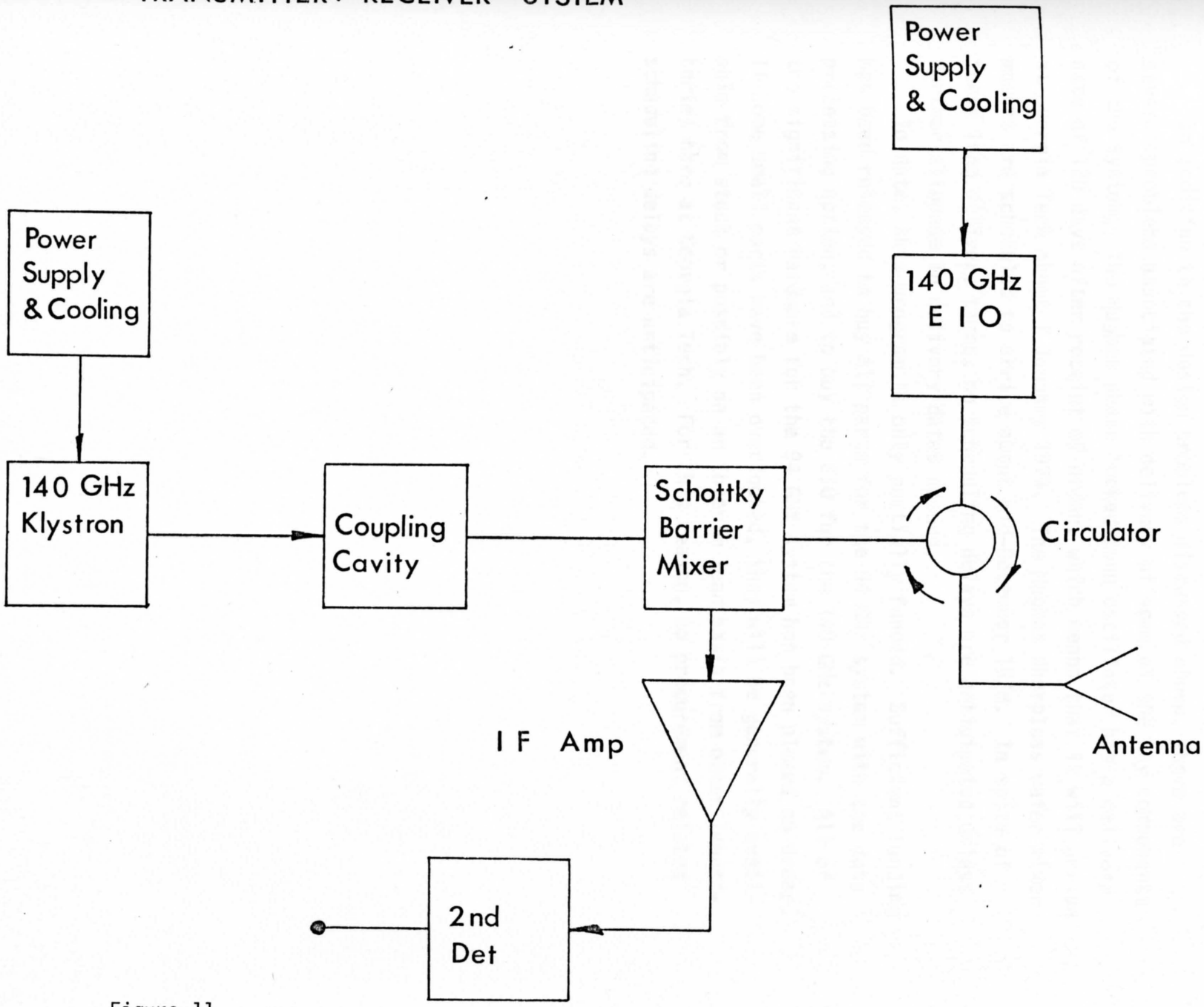


Figure 11.

4.0 PROCUREMENT AND SCHEDULING PROBLEMS

In addition to the design problems discussed above, there are several problems associated with delivery of some of the key components of the system. The Hughes phase locked Gunn oscillator has a delivery date of 120 days after receipt of order, which means that it will arrive at Georgia Tech about 1 January 1979. The Hughes Sharpless wafer mixer mounts are scheduled to arrive about mid-December 1978. In spite of these long delivery times, no scheduling delays are anticipated unless further slippage in delivery dates occurs.

To date, this program is only partially funded. Sufficient funding has been released to buy all parts for the 94 GHz system with the data processing option, and to buy the EIO for the 140 GHz system. All of the significant hardware for the 94 GHz system has been placed on order. If some small parts have been overlooked, they will be generally available from stock or possibly on an interim loan basis from other laboratories here at Georgia Tech. For this reason, no procurement related scheduling delays are anticipated.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 1 of 18

19 June 1978 through 30 June 1978

MILLIMETER GUIDANCE

TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

A tentative system design has been made for the 94 GHz coherent system (Unit 1) and the extended interaction oscillators (EIO) for both the 94 GHz and 140 GHz systems have been ordered. A detailed block diagram of the 94 GHz system has been drawn, and many of the parts have been chosen although nothing has yet been ordered except the EIO mentioned above.

The 94 GHz system will use a phase lock circuit devised by Henry [1], which has the ability to lock the klystron to a standard from any frequency on the klystron mode. A unique "pull-in" circuit, used with a conventional phase lock circuit, effects this locking. Present planning calls for the use of a phase locked Gunn source as a local oscillator with the injection locking klystron being locked to this source by the Henry circuit. This approach gives an all solid state receiver. The Henry circuit will also be used to lock the klystrons used in the frequency translation system.

PROBLEMS ENCOUNTERED

None

WORK TO BE PERFORMED NEXT PERIOD

All parts required for the fabrication of Unit 1 will be ordered, and initial design of this unit will be completed.

COST INFORMATION

In subsequent reports, cost information will be given in detail on a separate sheet, but this program was initiated too late in June to allow financial data to be entered into the computer. During June a total of $1,675.86 was spent on this program, of which $944.94 was personal services, $642.56 was overhead, and $88.36 was retirement.

REFERENCE

P. S. Henry, "Frequency-Agile Millimeter-Wave Phase Lock System", Rev. Sci. Instrum., Vol. 47, No. 9, (Sept., 1976), pp. 1020-1025.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 2 of 18

1 July 1978 through 20 July 1978

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Aresenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

WORK PERFORMED DURING THIS PERIOD

The preliminary system design for the 94 GHz coherent system is essentially complete, and most of the long-lead parts have been ordered. The remainder of the parts will be ordered when a final decision is made on the receiver intermediate frequency. Because of difficulties encountered at Georgia Tech with nearby strong commercial stations operating within IF bandwidths, it is necessary to choose the IF with care. A klystron phase lock system designed by P.S. Henry uses an IF of 740 GHz (which would equal the receiver IF in our system), and it would be convenient to use this frequency because most of the phase locking circuitry could be based on his design. However, a commercial UHF television band covers the range 512-806 GHz but the FCC regional office in Atlanta advises that channels above 50 (686-692 GHz) are not generally allocated, so that 740 GHz should lie in a fairly quiet region of the spectrum. Based on these considerations, it appears likely that this frequency would be the best choice for a system IF.

Some detailed information on phase locking has been received from P. S. Henry of Bell Laboratories. This information will save time in component selection and design. It is anticipated that the same phase lock loop design will be used for locking the EIO, except for design modifications required by the fact that EIO electrodes operate at much higher potentials.

Don Lochhead of TRW in Redondo Beach, California was contacted about the possibility of using a saw oscillator in the frequency translator system. TRW has used these oscillators in their other systems, but have not yet arranged to market them through their Airtech subsidiary, so it does not seem likely that this type device can be used. Bulk acoustic wave oscillators for this application were discussed with Joel Raymond of Teledyne MEC in Palo Alto, California. Joel was very cooperative, and is sending us a I-25 GHz acoustic delay line which together with an amplifier and circulator, can be used to build an oscillator. If we are pleased with the performance of this device, he will build a delay line for us at the frequency of our choice.

PROBLEMS ENCOUNTERED

Varian of Canada, who will be building our EIO's, has extended the delivery dates of the 94 and 140 GHz devices to 150 and 210 days ARO, respectively, from 120 and 130 days. This problem will be discussed with them in an attempt to get an earlier delivery.

WORK TO BE PERFORMED NEXT PERIOD

The remainder of the parts for Unit 1 will be ordered, and techniques for phase locking the EIO's will be studied.

Cost Information

The following charges have been incurred against the contract during the period

Personal Services (PS)	$1,988.54
Materials and Supplies	0.24
Travel	- 0-
Overhead (@76% of PS)	1,511.29
Retirement (@9.83% of PS)	195.47
TOTAL	$3,695. 54

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 631.30	37
Senior Research Engineers	1,339.21	80
Research Engineers	-0-	-0-
Assistant Research Engineers	-0-	-0-
Student Assistants	-0-	-0-
Technicians, Machinists	-0-	-0-
Clerical	18.03	3.5
TOTAL	$1,988.54	120.5

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$32,025	$2,933.48	$29,091.52
Materials and Supplies	154,988	0.24	154,987.76
Travel	500	-0-	500.00
Computer	-0-	-0-	-0-
Overhead	24,339	2,153.85	22,185.15
Retirement	3,148	283.83	2,864.17
AS PROPOSED	$ 215,000	$5,371.40	$209,628.60

Based on partial funding, the funding and equivalent man hours are sufficient to complete the tasks. Approximately 9.2% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 3 of 18

1 August 1978 through 31 August 1978

MILLIMETER GUIDANCE

TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

September 21, 1978

WORK PERFORMED DURING THIS PERIOD

After discussing commercial frequency allocation with the FCC, it was decided to use an intermediate frequency of 750 MHz for the 94 GHz system. This frequency is within the commercial UHF television band, but channels above 692 MHz are rarely allocated so that 750 MHz should lie within a fairly quiet region of the electromagnetic spectrum. An added advantage of this choice is that the Henry phase lock circuit, which will be used in these systems, has an IF of 740 MHz, and the components already chosen by Henry may also be used in our system. Many of these components have already been received.

A suggestion for a method of electronic frequency control of the 94 GHz EIO has been received from Mitch Evans of Varian Canada. A copy of his drawing is attached. Upon examination of this drawing, it appears that the most convenient injection point for the error voltage is across the resistor R as shown, because high voltage problems are eliminated. Injection at points X or Y presents problems with power supply capacitance or high voltage as suggested by the drawing notes. A disadvantage of this approach is that part of the EIO must be isolated from ground, which will also cause some capacitance problems for a phase lock system which must have a very fast response time.

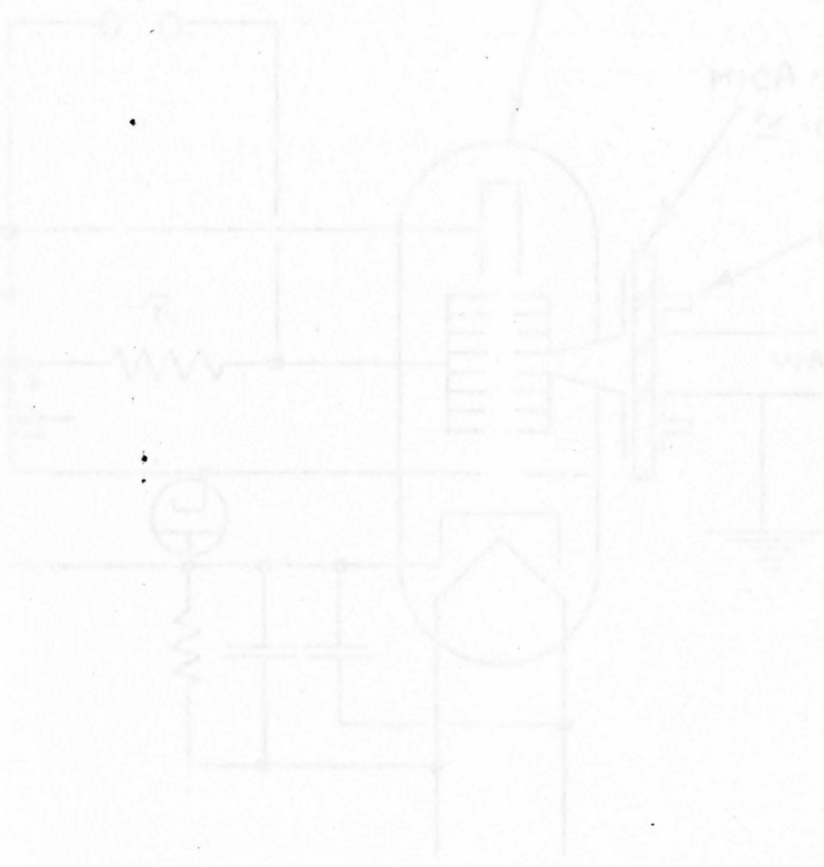
Doug Kennedy of Varian has indicated that the EIO's and klystrons ordered from Varian will probably be shipped in early October. Late delivery of these devices was cited as a problem in the last monthly letter, but October deliveries will not cause any schedule problems.

Bulk acoustic wave delay line samples have been received from Joel Raymond of Teledyne MEC. An oscillator will be constructed from one of these devices when time permits.

Because of long delivery times of mixers from Custom Microwave of Longmont, Colorado, it has been decided to buy Hughes mixer bodies and blank wafers, and to mount and contact our own didoes in them. The Hughes diodes will not be used because they employ silicon, which is considered inferior to GaAs for millimeter wave mixers. Hughes has agreed to furnish these devices to us in this way, but their delivery time is still 90 days, which may cause scheduling problems.

PROBLEMS ENCOUNTERED

The Hughes delivery time noted above, together with their delivery time of 120 days for the phase locked Gunn oscillator may cause scheduling problems.



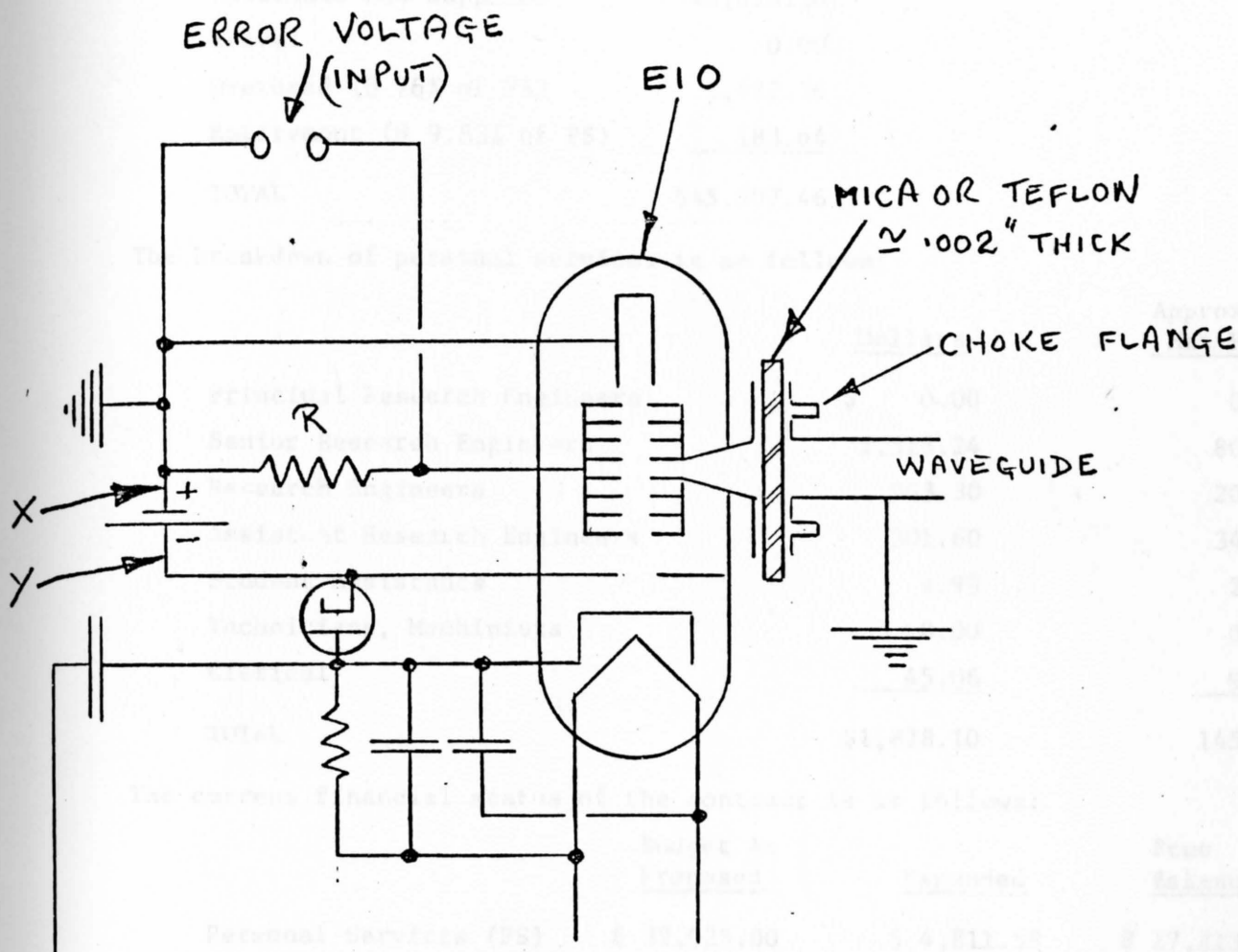
varian
ENGINEERING
SPECIFICATIONS

spec. no. _____

page ____ of ____

date _____

Specification: ELECTRONIC FREQUENCY CONTROL



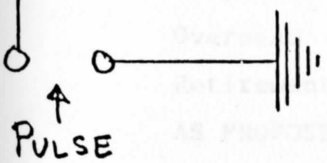
ERROR SIGNAL CAN BE INJECTED AS SHOWN (KEEP "R" SMALL ≪ 10KΩ)

OR:-

AT X (WATCH CAPACITY OF POWER SUPPLY ETC. TO GND.)

OR:-

AT Y (HIGH VOLTAGE PROBLEMS)



Rev

M109-6-67

Cost Information

The following charges have been incurred against the contract during the period 1 August to 1 September, 1978.

Personal Services (PS)	$ 1,878.10
Materials and Supplies	42,018.36
Travel	0.00
Overhead (@ 76% of PS)	1,427.36
Retirement (@ 9.83% of PS)	183.64
TOTAL	$45,507.46

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 0.00	0
Senior Research Engineers	1,318.24	80
Research Engineers	203.30	20
Assistant Research Engineers	301.60	34
Student Assistants	9.90	2
Technicians, Machinists	0.00	0
Clerical	45.06	9
TOTAL	$1,878.10	145

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 32,025.00	$ 4,811.58	$ 27,213.42
Materials and Supplies	154,988.00	42,018.60	112,969.40
Travel	500.00	0.00	500.00
Computer	0.00	0.00	0.00
Overhead	24,339.00	3,581.21	20,757.79
Retirement	3,148.00	467.47	2,680.53
AS PROPOSED	$215,000.00	$50,878.86	$164,121.14

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 15% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 4 of 18

1 September 1978 through 30 September 1978

MILLIMETER GUIDANCE

TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

October 19, 1978

WORK PERFORMED DURING THIS PERIOD

A review of the Georgia Tech approach to design and construction of the Millimeter Guidance Technology Hardware was held on Tuesday 5 October at MIRADCOM in Huntsville. This review concentrated on the design of the 94 GHz coherent system, including the data processing option, but preliminary design of the 140 GHz incoherent system was also discussed. The results of this review are being incorporated into a report which will be submitted to MIRADCOM upon completion.

FM noise in the 94 GHz phase locked Gunn oscillator has been discussed with George Ziff of Hughes Aircraft. Hughes has found that temperature stabilized crystal oscillators, which have very good long-term stability, generally have greater FM noise than crystals with poorer long term stability. Figure 1 is a copy of a plot furnished by Hughes which compares the FM noise output of these two types of crystals. These comparison measurements were made at 10.4 GHz so that the frequencies on the x-axis must be multiplied by 9.04 which is the ratio of 94 GHz to 10.4 GHz. Figure 2 shows a specification sheet for the FM noise of a 94 GHz radar. Although there appears to be some disparity between the two curves, Figure 1 clearly shows that the Hughes low noise crystal is superior to the high stability crystal with regard to FM noise. For this reason, the 94 GHz Gunn oscillator has been ordered with the Hughes low noise crystal. Note that the noise bandwidth used in making these comparisons is 1 kHz instead of 1 Hz.

Many parts for the 94 GHz system have been received, especially small parts for the phase lock system. Also, the 94 GHz injection locking klystron has been received with no problems from U. S. Customs. This tube has an output of 450 mW at 94.0 GHz.

PROBLEMS ENCOUNTERED

No significant problems arose during this reporting period.

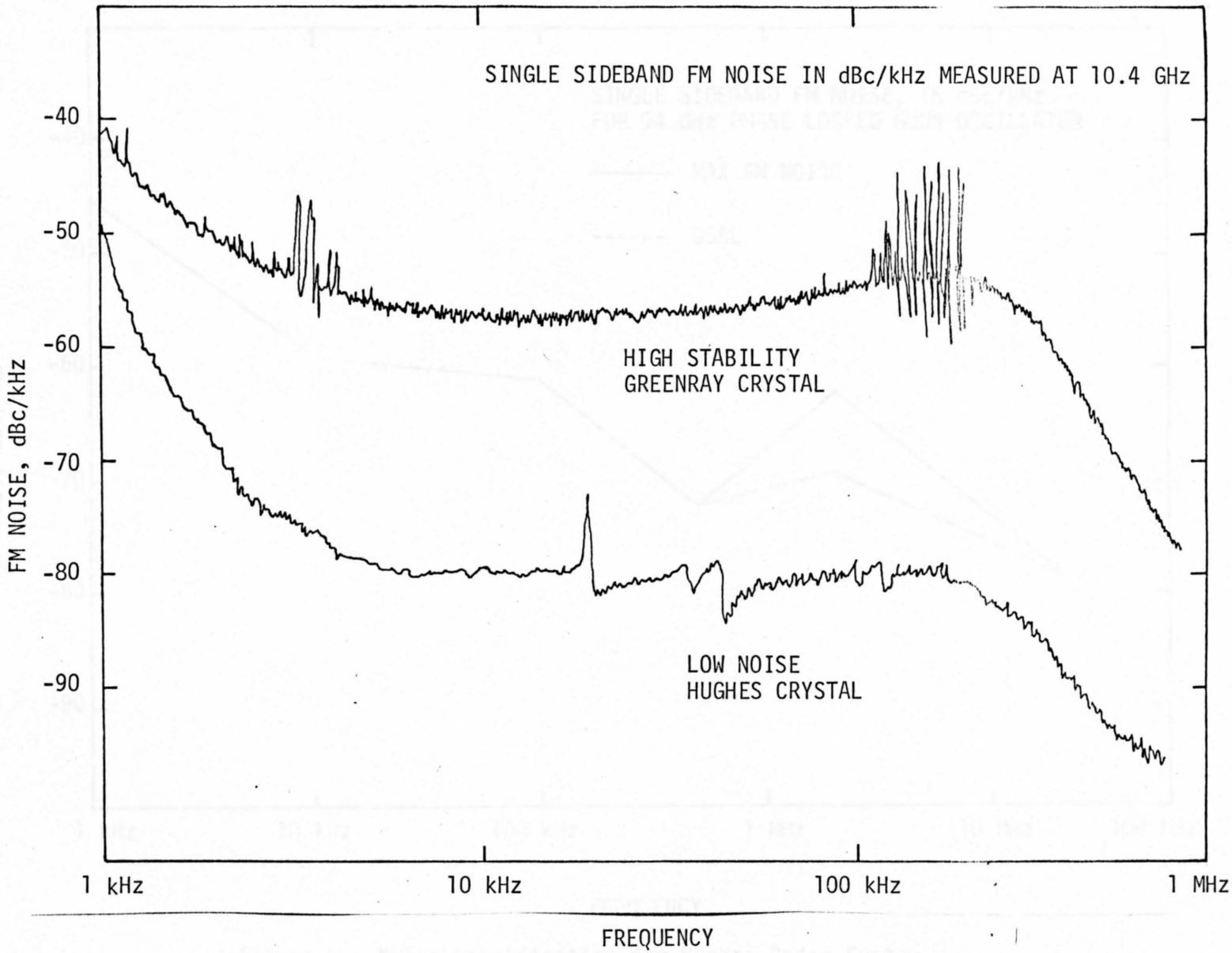


Figure 1. Noise Comparison of High Stability and Low Noise Crystals at 10.4 GHz.

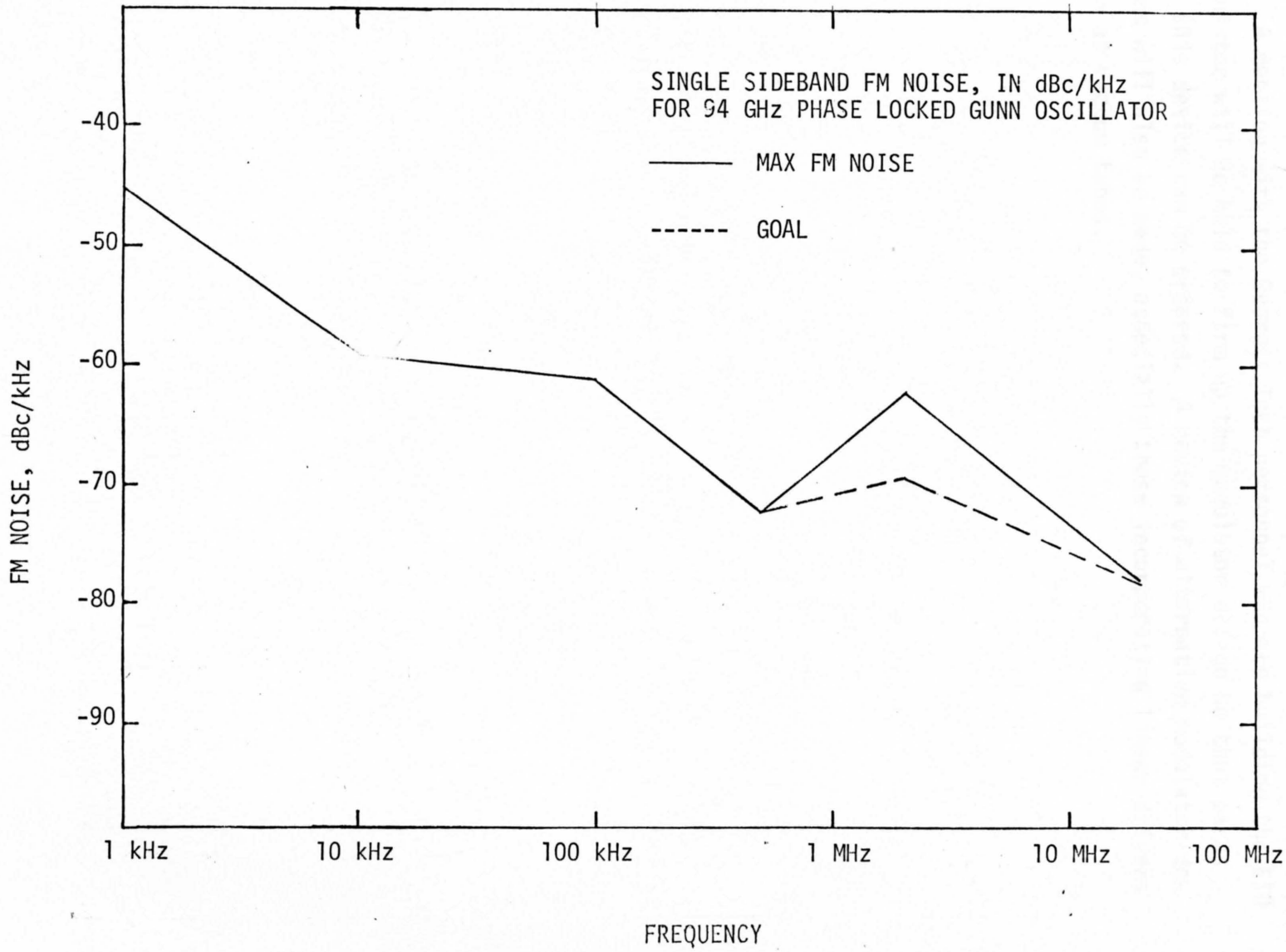


Figure 2. Noise Specification for Hughes Radar System.

PLANS FOR NEXT PERIOD

A meeting with the Georgia Tech personnel who are building the EIO modulator will be held to firm up the modulator design so that parts for this device can be ordered. A review of alternative modulator designs will also be made, especially those incorporating linear drivers such as vacuum tubes.

Cost Information

The following charges have been incurred against the contract during the period 1 September to 30 September, 1978.

Personal Services (PS)	3,993.05
Materials and Supplies	37,032.74
Travel	0.00
Overhead (@ 76% of PS)	3,034.72
Retirement (@ 9.83% of PS)	371.65
TOTAL	$44,437.16

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$1,262.60	74
Senior Research Engineers	1,315.21	79
Research Engineers	203.30	20
Assistant Research Engineers	603.21	68
Student Assistants	212.30	48
Technicians, Machinists	351.37	35
Clerical	45.06	9
TOTAL	$3,993.05	333

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 32,025	$ 12,720.37	$ 19,304.63
Materials and Supplies	154,988	79,051.34	75,936.66
Travel	500	0.00	500.00
Computer	0	0.00	0.00
Overhead	24,339	9,743.07	14,595.93
Retirement	3,148	1,276.88	1,871.12
AS PROPOSED	$215,000	$102,791.66	$112,208.34

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 40% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 5 of 18

1 October 1978 through 31 October 1978

MILLIMETER GUIDANCE
TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

November 15, 1978

WORK PERFORMED DURING THIS PERIOD

A meeting was held between personnel of the Electromagnetics Laboratory (EML) and the Radar and Instrumentation Laboratory (RAIL) to discuss design approaches for the EIO modulators to be used both on this program and the Harry Diamond Laboratory transmitters. Those in attendance were Jerry Eaves and Clark Butterworth of RAIL and J. J. Gallagher, R. G. Shackelford, Wayne Penn, and R. W. McMillan of EML.

The RAIL people favor a gas tube modulator with associated pulse forming network (PFN) similar to the design discussed at the recent design review held at MIRADCOM. They feel that the cathode capacitance of the EIO is much too high to charge quickly with the limited current available from vacuum tubes. Also, they believe that the EIO will be much less likely to be damaged by a circuit failure because the PFN stores only a small amount of energy. Subsequent measurement of the EIO cathode capacitance showed that it is not as high as originally believed, so that the vacuum tube modulator is still a viable option from the point of view of capacitance, but the potential EIO damage problem remains.

The EML people originally favored a vacuum tube modulator because of the ability of this type device to deliver a very flat pulse, which will make EIO phase and injection locking much easier.

If this approach is taken, some means of protecting the EIO from circuit failures will have to be devised. Recent meetings have discussed these approaches in more detail, and it appears that a decision on the best approach will be made within a few days.

Small parts for the 94 GHz system are being received almost every day; but the important components, namely the Gunn oscillator and the mixers, will not be delivered until early January. Fabrication of the phase lock loop electronic circuitry will begin within about a week, but little else can be done on the electronics until these critical items are received.

PROBLEMS ENCOUNTERED

The modulator design approach and the long delivery of critical components, as discussed above, are the only problems encountered during this reporting period.

PLANS FOR NEXT PERIOD

The modulator design approach will be decided upon and work on this circuit will begin. The phase lock loop electronics will be built and tested using the circuit diagrams obtained from P. S. Henry of Bell Laboratories.

Cost Information

The following charges have been incurred against the contract during the period 1 October to 31 October 1978:

Personal Services (PS)	$ 4,214.98
Materials and Supplies	8,727.33
Travel	372.67
Overhead (@ 76% of PS)	3,203.38
Retirement (@ 9.83% of PS)	332.60
TOTAL	$16,850.96

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 631.30	37
Senior Research Engineers	2,512.66	151
Research Engineers	101.65	10
Assistant Research Engineers	416.94	47
Student Assistants	383.55	87
Technicians, Machinists	123.82	12
Clerical	45.06	9
TOTAL	$4,214.98	353

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 32,025	$ 13,019.61	$ 19,005.39
Materials and Supplies	154,988	87,778.67	67,209.33
Travel	500	372.67	127.33
Computer	0	0	0
Overhead	24,339	9,819.31	14,519.69
Retirement	3,148	1,171.72	1,976.28
AS PROPOSED	$215,000	$112,161.48	$102,838.02

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 41% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 6 of 18

MILLIMETER GUIDANCE
TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

December 20, 1978

WORK PERFORMED DURING THIS PERIOD

A review of the design status of the EIO modulators was held on 8 December at Georgia Tech. Those in attendance were Tom Barley, Gus Rast and Marty Alexander of MIRADCOM; Bob Shackelford, Clark Butterworth and Bob McMillan of Georgia Tech; and Mike Hulley of Varian. The basic modulator design discussed was a hard tube circuit using an Eimac Y690 planar triode as the driver with its output coupled to the EIO cathode by a capacitor. Modulator performance and tube safety were emphasized during this review. The consensus of opinion of those present was that the design approach was satisfactory. Modulator tubes and high voltage power supplies have been ordered for this circuit. Mike Hulley gave some interesting insights into EIO electron gun and magnet structure design. Based on this discussion, a proposal to modify the contract to allow purchase of the EIO's for the beamrider laboratory with the newer, less bulky samarium-cobalt magnets, which would greatly reduce magnetic shielding problems for the ferrite devices in the transmitter/receiver circuitry, will be submitted.

Many small parts for the 94 GHz system are being received, including the Hughes mixers, which were not expected until early January. Enough parts have been received to assemble and test the phase lock circuitry in an open loop configuration, and this assembly is currently being done. The ac circuitry will be tested by injecting a 750 MHz signal into the input of the phase/frequency sensitive circuitry and observing dc level changes at its output. The dc circuitry will be tested by connecting it to the output of the ac circuit. Final testing of this phase lock loop cannot be accomplished until the 94 GHz phase locked Gunn oscillator is received from Hughes in early January.

Diode and whisker pins for the Hughes mixers were not ordered because of a misunderstanding of the IF bandwidth capability of the filters inherent in these pins. This misunderstanding has been resolved, and the pins will probably be furnished by Hughes. If not, they will be fabricated in one of the EES machine shops.

PROBLEMS ENCOUNTERED

No problems were encountered during this reporting period.

PLANS FOR NEXT PERIOD

Testing of the phase lock loop circuitry will begin. If diode and whisker pins can be obtained, the Hughes mixers will be contacted and characterized. Work on the modulator will begin.

Cost Information

The following charges have been incurred against the contract during the period 1 October to 31 October 1978.

Personal Services (PS)	$2,573.03
Materials and Supplies	1,281.94
Travel	0.00
Overhead (@ 76% of PS)	1,955.50
Retirement (@ 9.83% of PS)	236.46
TOTAL	$6,046.93

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 0.00	0
Senior Research Engineers	1,631.30	98
Research Engineers	729.17	75
Assistant Research Engineers	0.00	0
Student Assistants	167.50	40
Technicians, Machinists	0.00	0
Clerical	45.06	9
TOTAL	$2,573.03	220

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 32,025	$ 15,592.64	$16,432.36
Materials and Supplies	154,988	89,060.61	65,927.39
Travel	500	372.67	127.33
Computer	0	0.00	0.00
Overhead	24,399	11,774.81	12,564.19
Retirement	3,148	1,408.18	1,739.82
AS PROPOSED	$215,000	$118,208.91	$96,791.09

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 49% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

REPORT NO. 7 of 18

MILLIMETER GUIDANCE

TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158

(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

January 17, 1979

WORK PERFORMED DURING THIS PERIOD

Work on the EIO modulator has begun in the Radar and Instrumentation Laboratory of the Engineering Experiment Station. This laboratory has been given a sub-budget from Electromagnetics Laboratory Beamrider funds to design and build this modulator. Cathode and anode power supplies have been ordered, with delivery expected in early February. Modulator switch tubes have already been received.

Diode and whisker pins for the Hughes mixers have also been received. These mixers were originally ordered without pins because the IF bandpass characteristics of the Hughes filter pins was not known. George Ziff of Hughes very kindly supplied these pins without additional charge. The mixers for the 94 GHz system can now be contacted, a task which will be accomplished when the diode lab schedule permits - probably before mid-February.

The parts for the Henry phase lock loop discriminator have been received, and this sub-circuit has been assembled and made to operate. The linear range of this discriminator is about 100 MHz, which means that the phase lock will capture a tube within the range $\pm$ 50 MHz from the center frequency. This number compares favorably with the range scaled from the discriminator output photograph in Henry's paper. However, our discriminator is not well-behaved outside this range, and the layout is being changed in an attempt to improve this performance.

PROBLEMS ENCOUNTERED

No problems were encountered during this reporting period.

PLANS FOR NEXT PERIOD

The discriminator layout will be changed to improve performance. Breadboard construction of the dc amplifier portion of the phase lock will begin. The Hughes mixers will be contacted and characterized.

Cost Information

The following charges have been incurred against the contract during the period 1 December to 31 December 1978.

Personal Services (PS)	$ 5,514.72
Materials and Supplies	5,240.34
Travel	0.00
Overhead (@ 76% of PS)	4,191.19
Retirement (@ 9.83% of PS)	391.92
TOTAL	$15,338.17

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 727.07	40
Senior Research Engineers	1,318.24	79
Research Engineers	2,086.14	209
Assistant Research Engineers	148.91	19
Student Assistants	1,189.30	284
Technicians, Machinists	0.00	0
Clerical	45.06	9
TOTAL	$5,514.72	640

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 32,025	$ 21,107.36	$10,917.64
Materials and Supplies	154,488	94,300.95	60,687.05
Travel	500	372.67	127.33
Computer	0	0.00	0.00
Overhead	24,399	15,966.00	8,373.00
Retirement	3,148	1,800.10	1,347.90
AS PROPOSED	$215,000	$133,547.08	$81,452.92

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 66% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 8 of 18

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for
U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35807

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

February 14, 1979

WORK PERFORMED DURING THIS PERIOD

The phase lock discriminator has been made to work satisfactorily over a capture range of ± 100 MHz with no peaks or dips which might cause the klystron to be captured at a frequency other than the center frequency. Figure 1 is a plot of the discriminator voltage/frequency characteristic. To obtain the smooth curve, the Henry circuit was slightly modified by loading it with a .05 μf capacitor in parallel with a 47 Ω resistor. The center frequency is shown slightly displaced from 750 MHz because of the calibration of the sweep generator.

The IF amplifier has also been tested and shown to have a gain of 58 dB at 750 MHz with the filter and 60 dB without the filter. The bandwidth with the filter is 100 MHz and is 500 MHz with the filter removed.

The AGC feature of the phase lock IF amplifier has also been tested. This control input gives 30 dB of gain compression for a -10 volt input. The feedback circuit which drives this input is being designed.

A power output of 440 mW at 94 GHz has been obtained from the injection locking klystron. This tube has been used to test several small parts which have been received, namely detectors, an isolator, and a circulator.

Much of the receiver work is awaiting receipt of the 94 GHz Gunn oscillator from Hughes, which is scheduled to be shipped on 15 February. The local oscillator coupling cavity is being fabricated and should be ready before the oscillator arrives. The mixer has not yet been contacted because a new contacting jig must be fabricated in the machine shop. It is expected that the mixer, local oscillator, and the coupling cavity will all be available at about the same time so that the receiver can be assembled and tested.

PROBLEMS ENCOUNTERED

None.

PLANS FOR NEXT PERIOD

If current delivery schedules hold, all receiver parts will be available during the next reporting period, and receiver testing can begin. Transformers for the phase lock loop should also be received, and the dc electronics for that subsystem can then be tested.

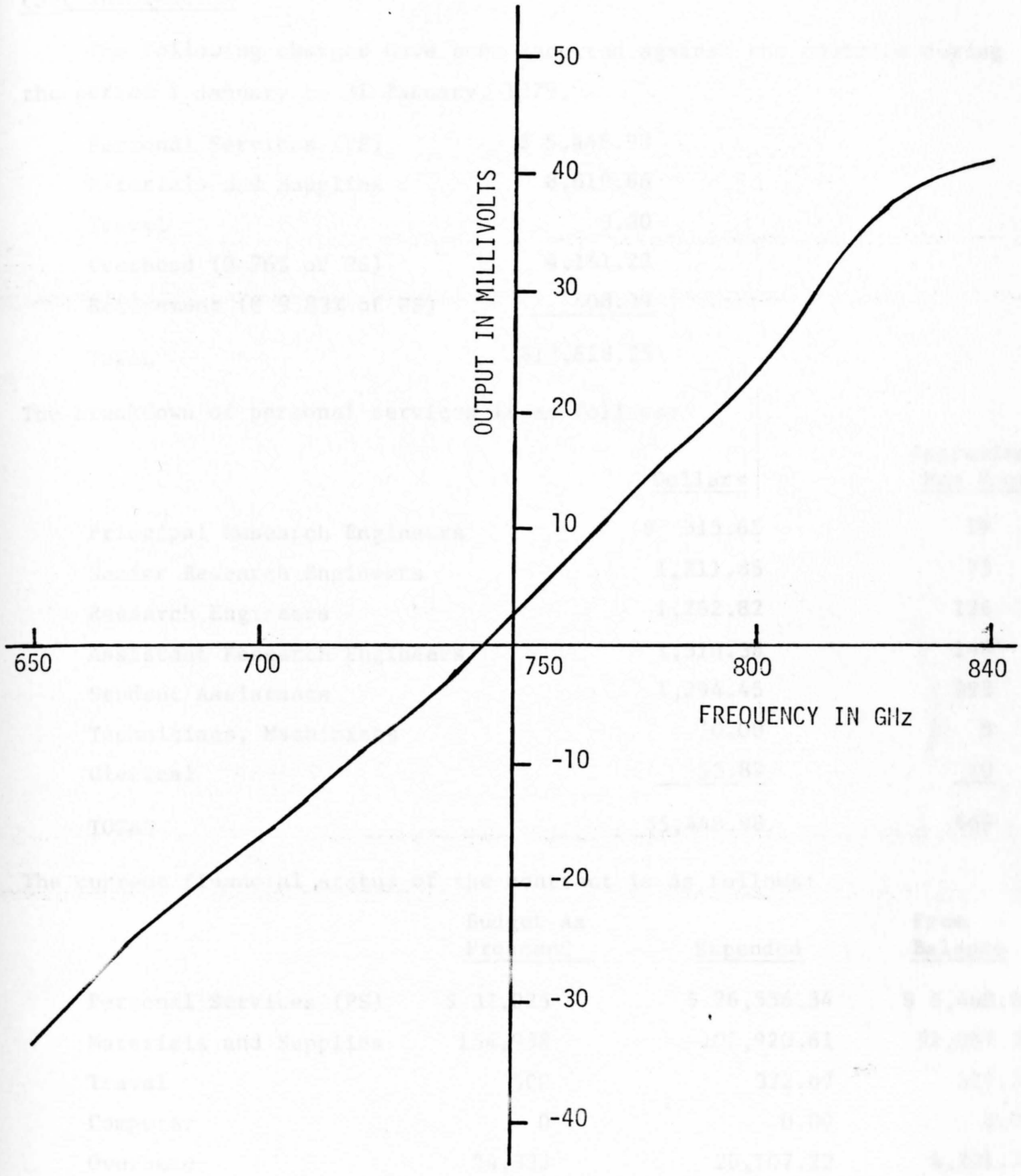


Figure 1. Phase Lock Discriminator Output Characteristic.

Cost Information

The following charges have been incurred against the contract during the period 1 January to 31 January, 1979.

Personal Services (PS)	$ 5,448.98
Materials and Supplies	8,619.66
Travel	0.00
Overhead (@ 76% of PS)	4,141.22
Retirement (@ 9.83% of PS)	408.39
TOTAL	$18,618.25

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 315.65	19
Senior Research Engineers	1,211.86	73
Research Engineers	1,262.82	126
Assistant Research Engineers	1,310.38	148
Student Assistants	1,294.45	293
Technicians, Machinists	0.00	0
Clerical	53.82	10
TOTAL	$5,448.98	669

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 32,025	$ 26,556.34	$ 5,468.66
Materials and Supplies	154,988	102,920.61	52,067.39
Travel	500	372.67	127.33
Computer	0	0.00	0.00
Overhead	24,339	20,107.22	4,231.78
Retirement	3,148	2,208.49	939.51
AS PROPOSED	$215,000	$152,165.33	$62,834.67

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 83% of the proposed task has been completed. This percentage does not include the recent increment of $100K added to the contract.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 9 of 18

1 February 1979 through 28 February 1979

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

March 29, 1979

WORK PERFORMED DURING THIS PERIOD

Further tests have been made on the phase lock loop circuit to verify operation of the phase sensitive detector loop. The output of the 750 MHz reference oscillator was split into two equal parts by a 3 dB power splitter. One of these outputs was fed into a trombone slide type phase shifter and from there to the signal input for the phase lock loop. The other output was used normally as a phase reference. A curve was then plotted of output voltage as a function of phase shift and a near perfect sine wave response was obtained. This curve is shown in Figure 1. However, a problem was noted in that the sine wave was not symmetrical about zero. Further tests are planned with other mixers to see if this problem recurs, but it is not considered serious because it can be compensated in the dc amplifiers which follow the phase detector mixer.

An AGC amplifier has been built for the phase lock loop. This amplifier was used by Paul Henry to control the output of the phase lock IF to prevent overdriving of the following circuits. This circuit is currently being tested. The dc amplifier circuits for the phase lock are being built. The transformers required for high voltage isolation have been received and it is expected that these circuits will be ready for test during the next reporting period.

Some difficulty has been experienced with contacting the Hughes mixers. Recent discussions with Paco Bernues of Hughes pointed out the need for extra support for the diode pins within the wafer. Additional rexolite bushings have been machined at EES to provide this support. In addition, the pin must be epoxied into the wafer to give good structual strength. A diode pin is currently ready to be

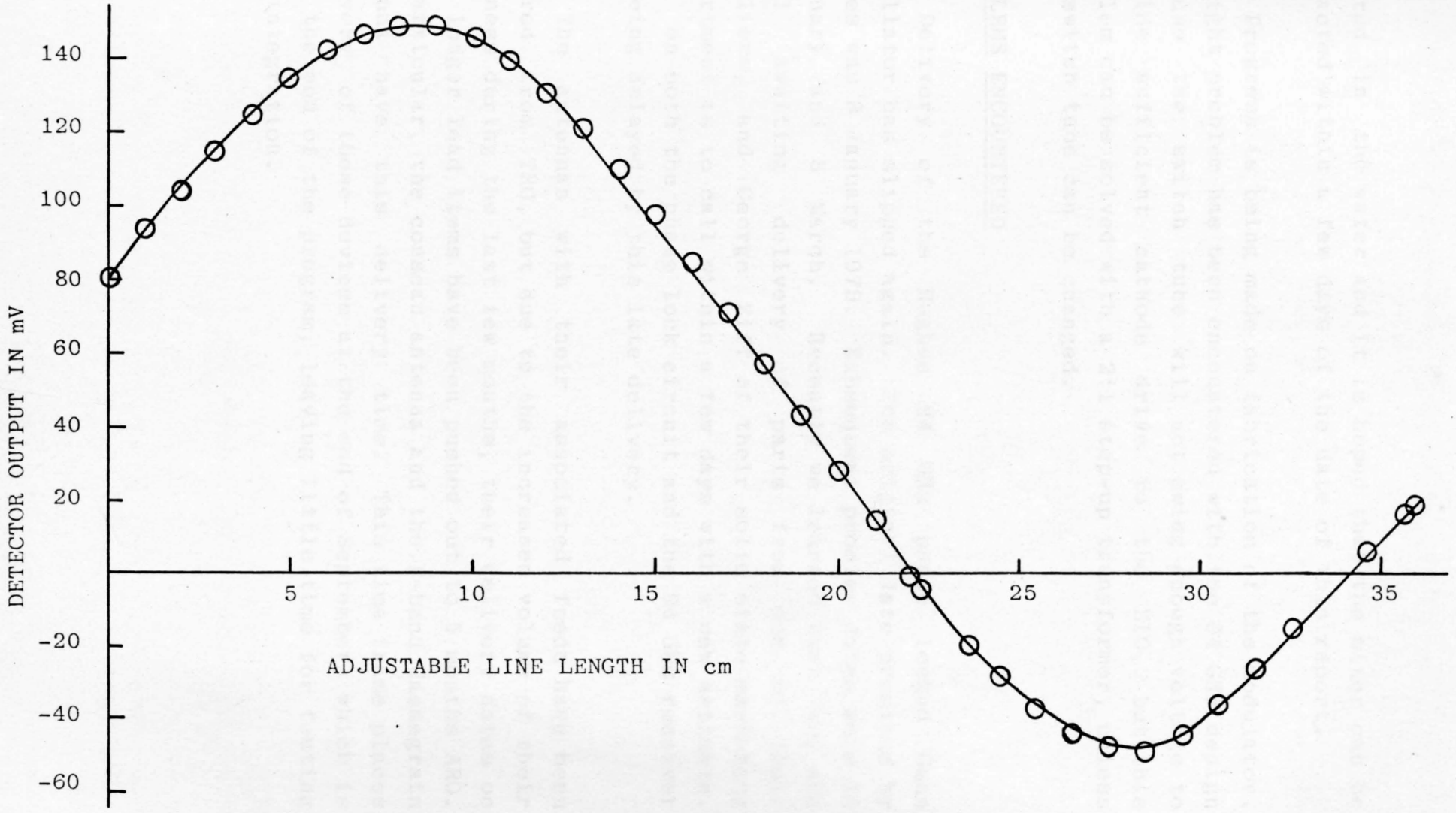


Figure 1. Output of Phase Detector as a Function of Phase Shift.

mounted in the wafer and it is hoped that the mixer can be contacted within a few days of the date of this report.

Progress is being made on fabrication of the modulator. A slight problem has been encountered with the 94 GHz design because the switch tube will not swing enough voltage to provide sufficient cathode drive to the EIO, but this problem can be solved with a 2:1 step-up transformer, unless the switch tube can be changed.

PROBLEMS ENCOUNTERED

Delivery of the Hughes 94 GHz phase locked Gunn oscillator has slipped again. The original date promised by Hughes was 8 January 1979. Subsequent promise dates were 15 February and 8 March. Recently we learned that they are still awaiting delivery of parts from one of their suppliers, and George Ziff of their solid state marketing department is to call within a few days with a new estimate. Work on both the phase lock circuit and the 94 GHz receiver is being delayed by this late delivery.

The antennas with their associated feeds have been ordered from TRG, but due to the increased volume of their business during the last few months, their delivery dates on the longer lead items have been pushed out to 5 months ARO. In particular, the conscan antenna and the F-band Cassegrain antenna have this delivery time. This time frame places delivery of these devices at the end of September, which is near the end of the program, leaving little time for testing and integration.

Cost Information

The following charges have been incurred against the contract during the period 1 February to 28 February 1979.

Personal Services (PS)	$ 8719.29
Materials and Supplies	2037.60
Travel	0.00
Overhead (@ 76% of PS)	6626.66
Retirement (@ 9.83% of PS)	665.94
TOTAL	18049.49

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	0.00	0
Senior Research Engineers	1972.18	119
Research Engineers	3329.95	333
Assistant Research Engineers	1799.85	203
Student Assistants	1145.91	259
Technicians, Machinists	426.34	43
Clerical	45.06	9
TOTAL	8719.29	966

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 67,833	$ 37,904.13	$ 29,928.87
Materials and Supplies	187,746	105,358.42	82,387.58
Travel	1,200	372.67	827.33
Computer	0	0.00	0.00
Overhead	51,553	28,731.54	22,821.46
Retirement	6,668	3,103.25	3,564.75
AS PROPOSED	$315,000	$175,470.01	$139,529.99

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 56% of the proposed task has been completed. This estimate is based on percentage of personal services expended and includes the recent $100K increment.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 10 of 18

1 March 1979 through 31 March 1979

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

April 11, 1979

WORK PERFORMED DURING THIS PERIOD

The 750 MHz mixer with the output unsymmetrical about zero described in the last monthly progress report was found to be defective. A total of four of these mixers was purchased for the two phase lock systems, in which they are used as phase detectors in the in-phase and quadrature loops. The other three mixers were subsequently tested in one of the phase detector circuits and were found to give symmetrical outputs with about 50% more voltage than the defective mixer. The faulty mixer has been returned to Mini-Circuits Lab for replacement. Figure 1 is a plot of voltage output as a function of phase shift for one of the good mixers.

Dr. John Kuno of Hughes Aircraft called to give the status of the 94 GHz phase locked source that will be used as a receiver local oscillator and phase lock reference for this program. The source has been tested and is working, but cannot be shipped until a crystal of the proper frequency has been received. Apparently this device was tested with a substitute crystal. It will be recalled that the specifications for this crystal were changed early in the program to get improved short-term stability.

A different switch tube is being tried in the EIO modulator to avoid using the 2:1 step-up transformer mentioned in the last report. This tube is a type 4PR60 tetrode, and an attempt will be made to simultaneously drive both screen and control grid to establish a modulation "pedestal" on which a high speed pulse can be superimposed. It is expected that some results from this approach will be available before the next monthly report.

One of the Hughes mixers has been successfully contacted, but noise figure measurements gave 12-15 dB, which is not acceptable. Since spare wafers were ordered for each of these mixers, a total of six wafers is available, and one or more of these will be contacted and tried with hopefully better results. It may also be necessary to build an IF

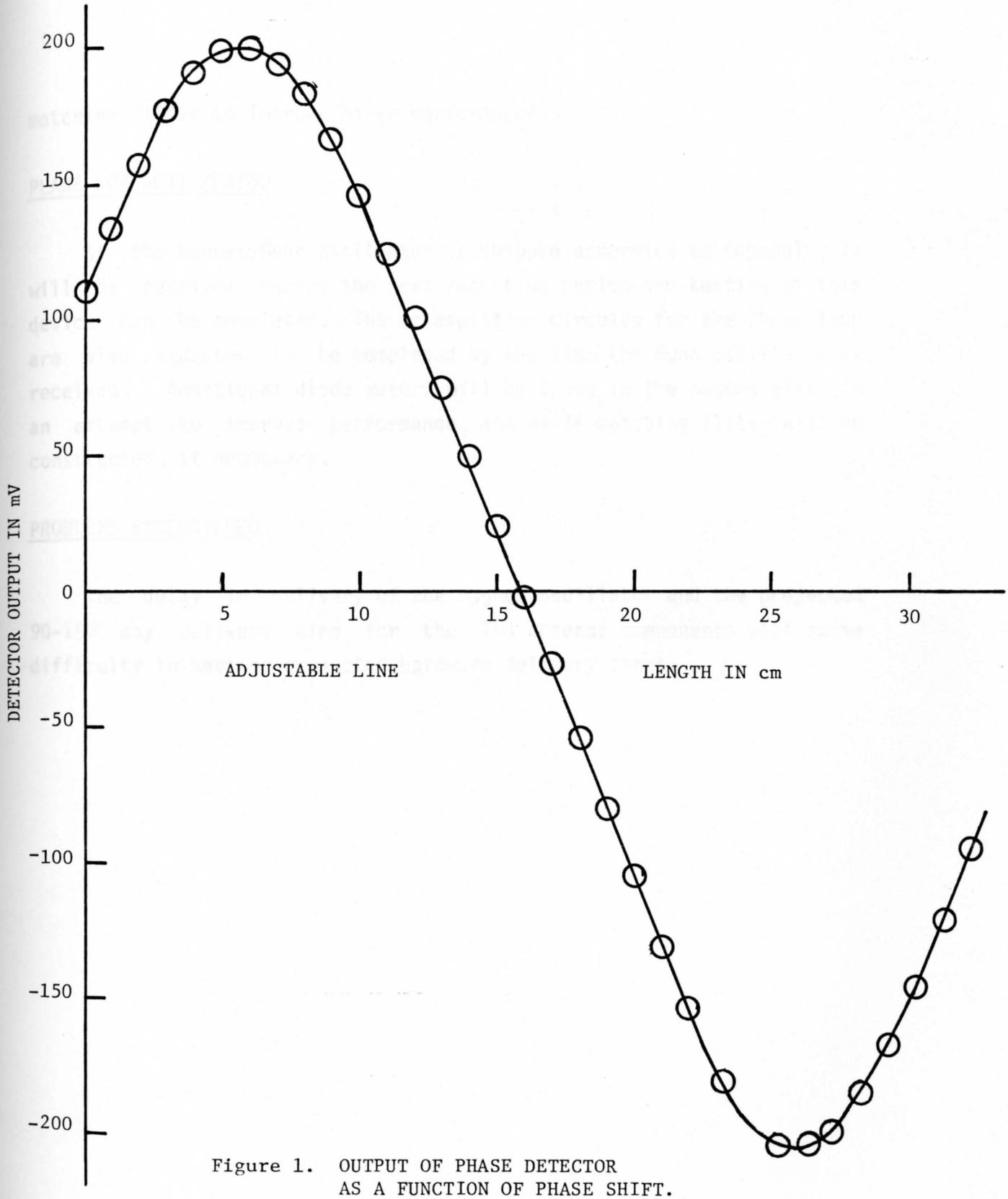


Figure 1. OUTPUT OF PHASE DETECTOR AS A FUNCTION OF PHASE SHIFT.

matching filter to improve mixer performance.

PLANS FOR NEXT PERIOD

If the Hughes Gunn oscillator is shipped according to schedule, it will be received during the next reporting period and testing of this device can be completed. The dc amplifier circuits for the phase lock are also expected to be completed by the time the Gunn oscillator is received. Additional diode wafers will be tried in the Hughes mixer in an attempt to improve performance, and an IF matching filter will be constructed, if necessary.

PROBLEMS ENCOUNTERED

The delay in delivery of the Hughes oscillator and the projected 90-150 day delivery time for the TRG antenna components will cause difficulty in meeting projected hardware delivery times.

Cost Information

The following charges have been incurred against the contract during the period 1 March to 31 March, 1979.

Personal Services (PS)	$ 6,753.77
Materials and Supplies	2,689.16
Travel	0.00
Overhead (@ 76% of PS)	5,132.87
Retirement (@ 9.83% of PS)	491.43
TOTAL	$15,067.23

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 157.83	9
Senior Research Engineers	449.40	27
Research Engineers	1,921.88	192
Assistant Research Engineers	3,102.92	350
Student Assistants	680.10	154
Technicians, Machinists	352.83	35
Clerical	88.81	18
TOTAL	$6,753.77	785

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 88,697.98	$ 44,657.90	$ 44,040.08
Materials and Supplies	148,972.34	108,047.58	40,924.76
Travel	1,200.00	372.67	827.33
Computer	0.00	0.00	0.00
Overhead	67,410.50	33,864.41	33,546.09
Retirement	8,719.18	3,594.68	5,124.50
AS PROPOSED	$315,000.00	$190,537.24	$124,462.76

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 50% of the proposed task has been completed. This estimate is based on percentage of personal services expended.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 11 of 18

1 April 1979 through 30 April 1979

MILLIMETER GUIDANCE
TECHNOLOGY HARDWARE

Project Director
R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

May 11, 1979

WORK PERFORMED DURING THIS PERIOD

Funding for all five of the basic units proposed for the millimeter guidance technology hardware system has been received. In addition, the tracker mount (including fabrication of corner cubes) and phase lock synchronizer units have been added to the basic system and these subsystems have also been funded. To assist in ordering parts for these units, block diagrams of each have been drawn, where appropriate, and these diagrams are shown as Figures 1-5. Note that the phase lock synchronizer of Figure 5 is used, with minor modifications, in the frequency translator of Figure 4 and also in the 94 GHz coherent system shown in Figure 1. These diagrams should be regarded as tentative because minor modifications will no doubt be required before the program ends.

Some progress has been made in the design of the EIO modulator driver. This circuit will drive the grid of the switch tube which in turn drives the EIO cathode. In the approach taken in this design, four separate waveforms are summed together to give a composite drive pulse which is compensated for EIO frequency chirp. These waveforms are shown in Figures 6a-d. The basic rectangular drive pulse is shown in Figure 6a. To provide fast charging for the interelectrode capacitance of the EIO, the pulse of Figure 6b is superimposed. The ramp waveform of Figure 6c is added to compensate for discharge of the energy storage capacitor during the pulse. Finally, the waveform of Figure 6d is used to give variability in drive shape to compensate for possible anomalies in EIO response. Each of these pulses is variable in amplitude, and the ramp waveform as well as the waveform of Figure 6d are also variable in slope.

The 94 GHz EIO has been shipped by Varian and should be in Atlanta as of the date of this writing (10 May). When this tube arrives, it will be tested in the gas tube modulator in the EES Radar and Instrumentation Laboratory. Figure 7 is a plot of output power and frequency as a function of beam pulse voltage for this tube. Note that the maximum power output is in excess of 1.5 kW, but based on measurements made on the 1 kW tube at EES, not all of this power will be useful because the frequency spectrum spreads severely when the tube is driven to its maximum limits. The best spectral characteristics for locking this tube will probably be obtained at a power output of a few hundred watts.

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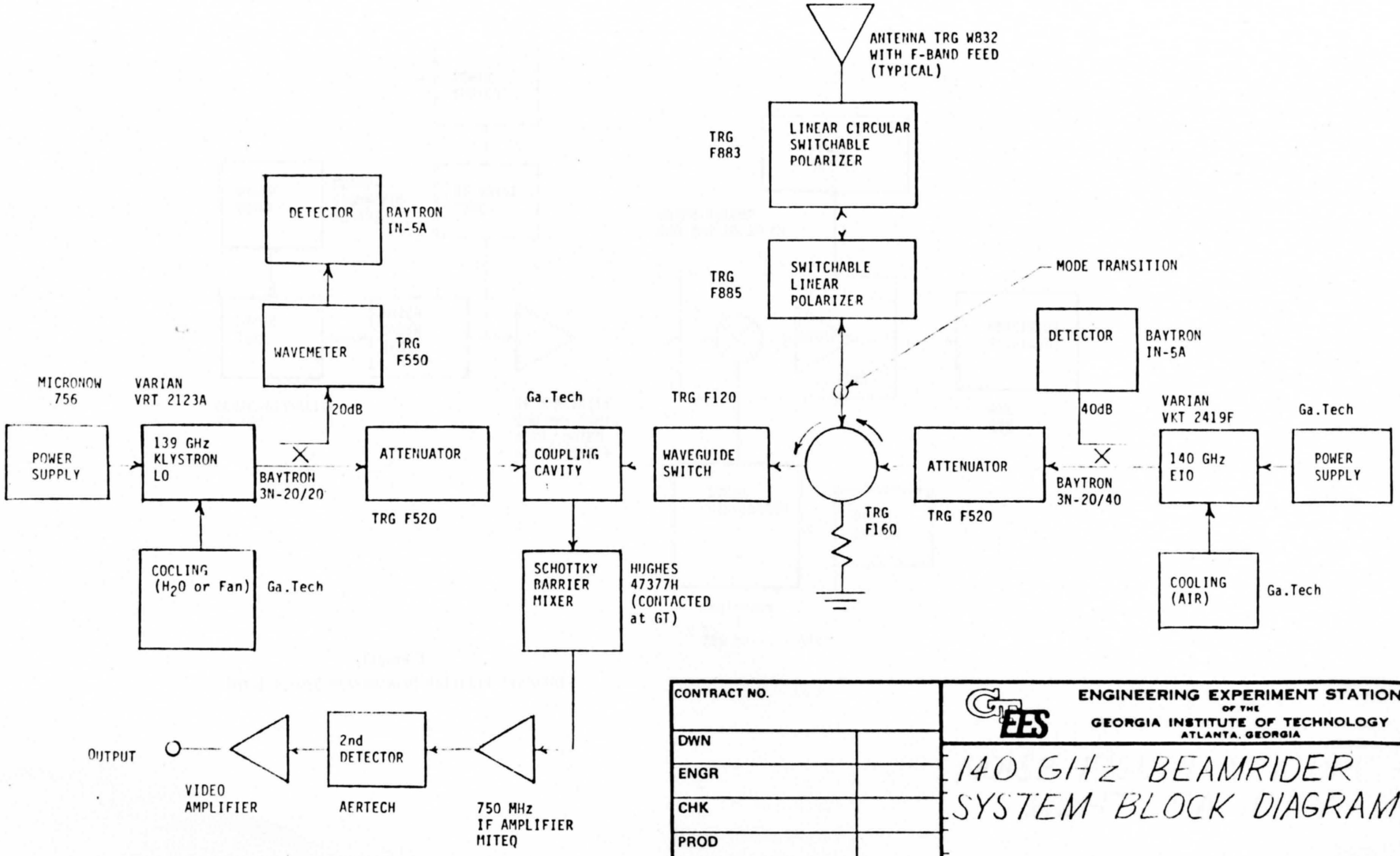


Figure 2
140 GHz BEAMRIDER SYSTEM BLOCK DIAGRAM (4/13/79)

CONTRACT NO.	ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA
DWN	140 GHz BEAMRIDER SYSTEM BLOCK DIAGRAM
ENGR	
CHK	
PROD	
APVD	SIZE: B; CODE IDENT NO.: ; DRAWING NO.: A-2166-007
APVD	SCALE: ; SHEET:

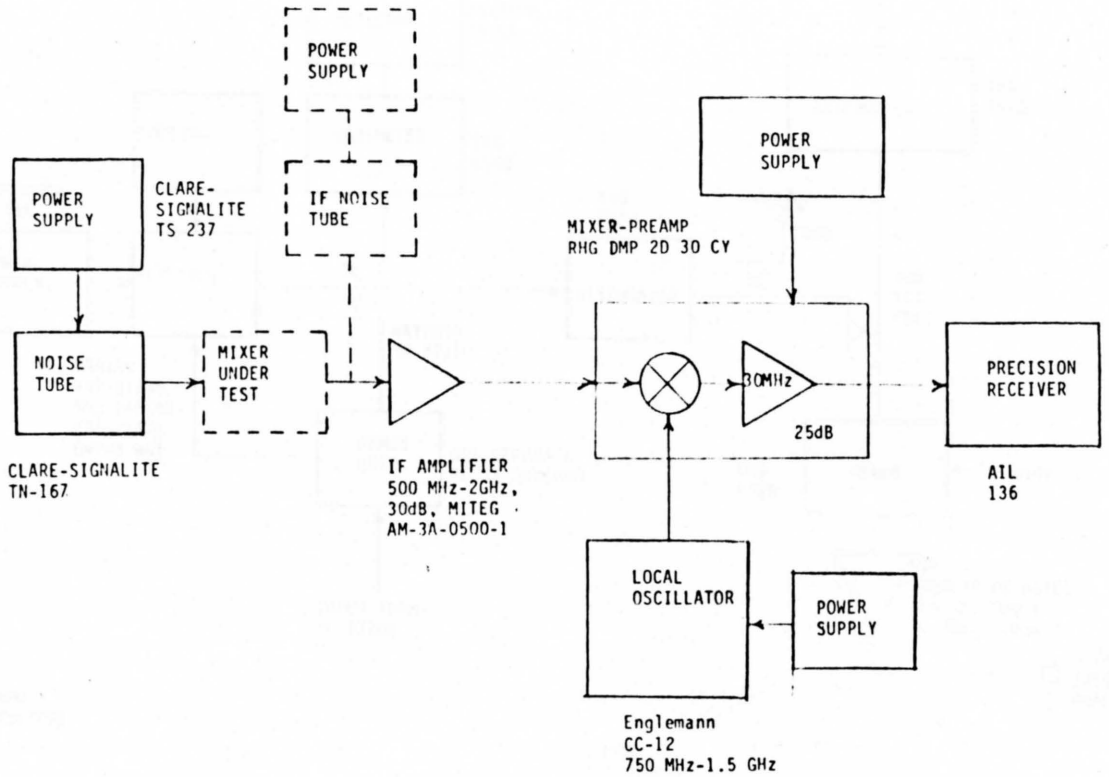


Figure 3

NOISE FIGURE MEASUREMENT FACILITY (5/2/79)

CONTRACT NO.		ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA	
DWN		NOISE FIGURE MEASUREMENT FACILITY	
ENGR			
CHK			
PROD			
APVD		SIZE: B	CODE IDENT NO.
APVD		DRAWING NO.: A-2166-00E	
		SCALE	SHEET

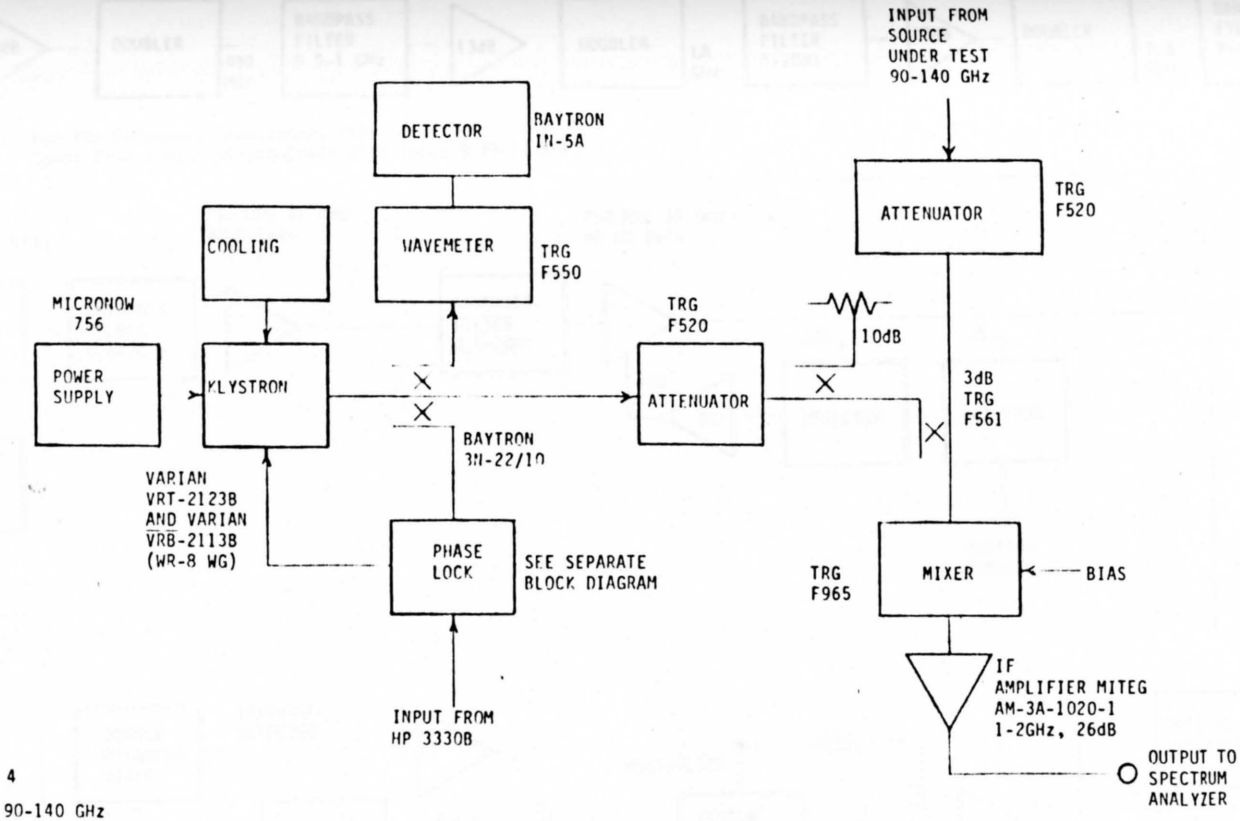


Figure 4

BLOCK DIAGRAM OF 90-140 GHz
FREQUENCY TRANSLATOR (4/26/79)

CONTRACT NO.	ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA
DWN	90-140 GHz FREQUENCY TRANSLATOR
ENGR	
CHK	
PROD	
APVD	SIZE: B; CODE IDENT NO.: ; DRAWING NO.: A-2166-009
APVD	SCALE: ; SHEET:

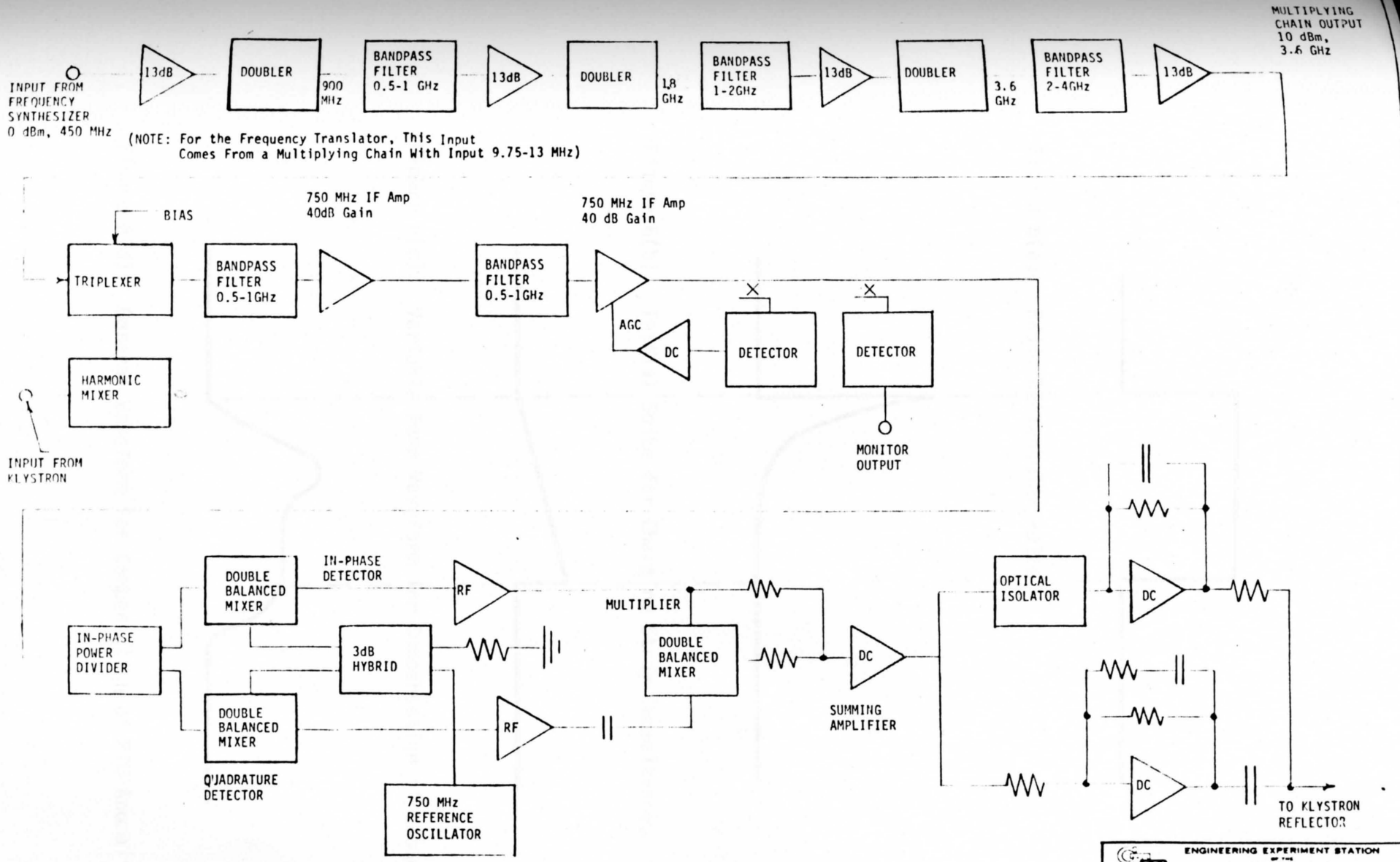


Figure 5

MILLIMETER WAVE KLYSTRON PHASE LOCK CIRCUIT (5/2/79)

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA GEORGIA

MILLIMETER WAVE KLYSTRON PHASE LOCK CIRCUIT

SIZE	CODE IDENT NO	DRAWING NO
B		A-2166-006

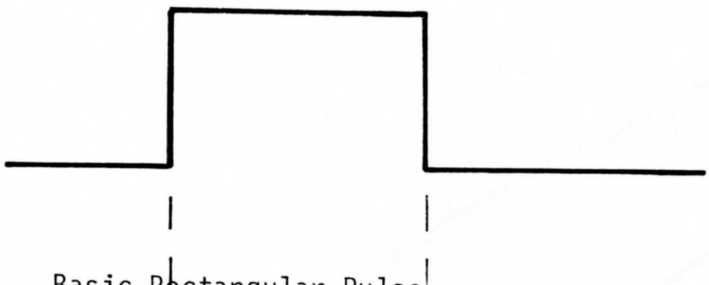


Figure 6(a). Basic Rectangular Pulse.

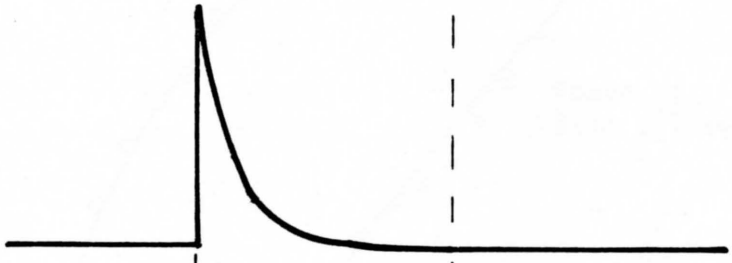


Figure 6(b). Initial Spike for Charging Stray Capacitance.

Figure 6(c). Variable Ramp Waveform for Compensation of Capacitor Discharge.

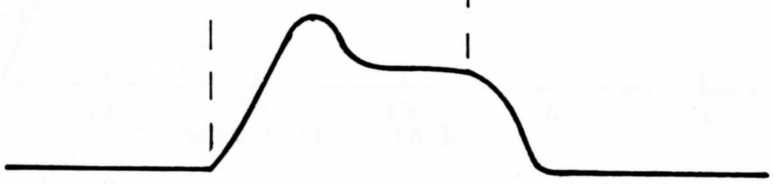


Figure 6(d). General Waveform for Compensation of EIO Anomalies.

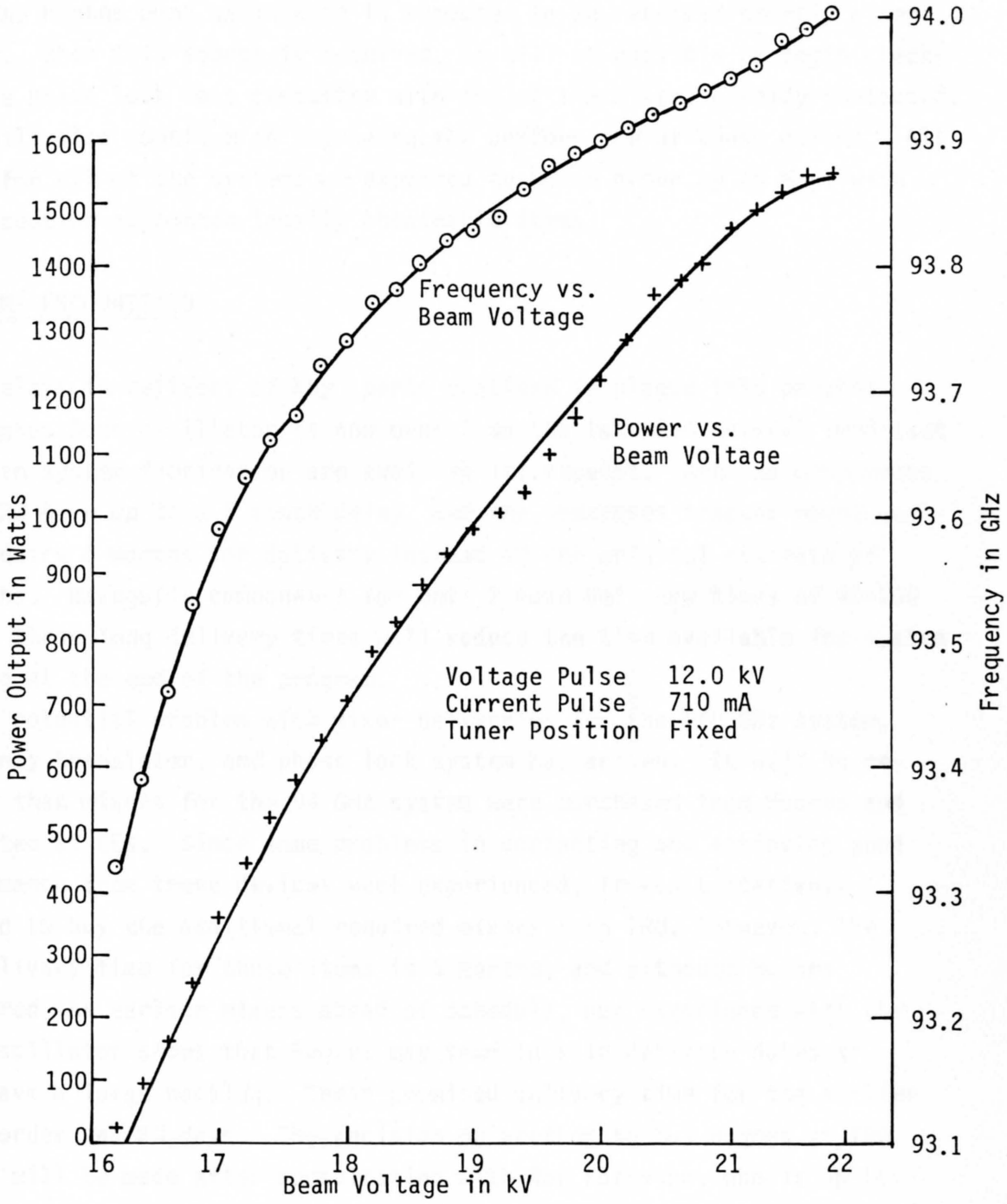


Figure 7. Power and Frequency vs. Beam Voltage for Varian 94 GHz EIO No. E0138.

PLANS FOR NEXT PERIOD

The Hughes Gunn oscillator is expected to be received shortly after 1 June. When this source is received, it will be possible to begin checking the phase lock loop circuitry with one of the mixers already contacted. Work will also continue on improving the performance of these mixers. All parts for all of the systems are expected to be on order by 15 May, with the exception of common locally obtainable items.

PROBLEMS ENCOUNTERED

Delays in delivery of key parts continue to plague this program. The Hughes Gunn oscillator is now over 5 months late and several important steps in system fabrication are awaiting its receipt. Antenna components from TRG have up to a 5 month delay, and the Contraves tracker mount may now require 6 months for delivery instead of the original estimate of 4 months. Waveguide components for Unit 2 have delivery times of 90-100 days. These long delivery times will reduce the time available for system testing at the end of the program.

A potential problem with mixer deliveries for the 140 GHz system, frequency translator, and phase lock system has arisen. It will be recalled that mixers for the 94 GHz system were purchased from Hughes and contacted at EES. Since some problems in contacting and achieving good performance from these devices were experienced, it was tentatively decided to buy the additional required mixers from TRG. However, the TRG delivery time for these items is 5 months, and although Hughes delivered the earlier mixers ahead of schedule, our experience with the Gunn oscillator shows that Hughes may tend to slip delivery dates if they have a large backlog. Their promised delivery time for the earlier mixer order was 80 days. The decision on whether to buy Hughes or TRG mixers will be made after consultation with Ron Forsythe, who is an EES engineer specializing in mixers, and after an input is received from Hughes on delivery date.

It should be noted that the preferred vendor for mixers at EES is Custom Microwave, but there appears to be no hope that an acceptable delivery date could be obtained from them.

Cost Information

The following charges have been incurred against the contract during the period 1 April to 30 April 1979.

Personal Services (PS)	$ 6,680.06
Materials and Supplies	24,753.96
Travel	0.00
Overhead (@ 76% of PS)	5,076.85
Retirement (@ 9.83% of PS)	556.39
TOTAL	$37,067.26

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 0.00	0
Senior Research Engineers	2,044.68	123
Research Engineers	1,200.18	120
Assistant Research Engineers	2,352.84	265
Student Assistants	1,019.80	231
Technicians, Machinists	0.00	0
Clerical	62.56	13
TOTAL	$6,680.06	752

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$132,952.98	$ 51,337.96	$ 81,615.02
Materials and Supplies	184,174.34	132,801.54	51,372.80
Travel	1,200.00	372.67	827.33
Computer	400.00	0.00	400.00
Overhead	101,044.50	38,941.26	62,103.24
Retirement	13,069.18	4,151.07	8,918.11
AS PROPOSED	$432,841.00	$227,604.50	$205,236.50

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 39% of the proposed task has been completed. This estimate is based on percentage of personal services expended.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 12 of 18

1 May 1979 through 31 May 1979

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. W. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

June 14, 1979

WORK PERFORMED DURING THIS PERIOD

The Hughes 93.25 GHz phase locked Gunn oscillator has been received and successfully tested. This source is phase mixed with a 7.8 GHz source which is in turn locked to a 97 MHz stable crystal oscillator. The twelfth harmonic of the 7.8 GHz source is compared to the 93.25 GHz Gunn output in a harmonic mixer to obtain a 97 GHz IF, which is compared in phase to the 97 GHz crystal oscillator output to generate a phase locking error signal. The Gunn oscillator is locked when the IF output has a narrow spectral bandwidth (< 1 KHz). Figure 1 is a photograph of this IF output taken from a spectrum analyzer. Note that this photograph indicates that the Gunn oscillator is locked. This oscillator has an output of 10.5 mW.

Using this stable Gunn oscillator output, it has been possible to lock the 94 GHz Varian klystron using the Henry locking circuit. Again, the bandwidth of the 750 MHz IF signal is a good indication that the tube is locked, and a photograph of the spectrum of this signal is shown in Figure 2. Another proof that the tube is locked is obtained by setting the wavemeter to resonate at the tube frequency and varying the klystron reflector voltage while observing the detected wavemeter output on a scope. The high Q of the wavemeter would cause fluctuations in detected power if the tube were not locked, and no such fluctuations were observed. Some additional work needs to be done to extend the tube locking range to cover the entire oscillation mode, and to clean up some of the circuitry to obtain a stronger and quieter lock. This work is now being done.

Both the 94 and 140 GHz EIO's have been received from Varian, and apparently meet or exceed all specifications. Data sheets for these tubes are attached to this report.

The method of driving the EIO cathode by using a tetrode which is turned on by exciting both its control and screen grids does not provide enough voltage swing to give good EIO output. As a result it has been decided to buy triodes from Eimac which have a voltage rating of 25 kV to achieve the desired swing of 13 kV for the 94 GHz tube with good linearity. The earlier lower voltage triode design will be used for the 140 GHz EIO because this tube operates at a voltage of 8 kV.

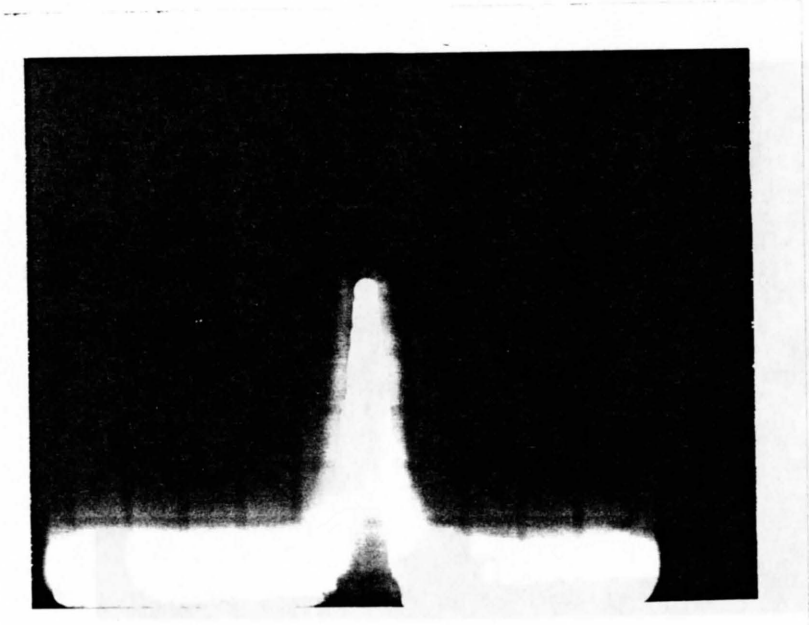


Figure 1. Photograph of 97 MHz IF Output of Phase Locked Gunn Oscillator, Horizontal Scale 1 kHz/div, Vertical Scale 10 dB/div

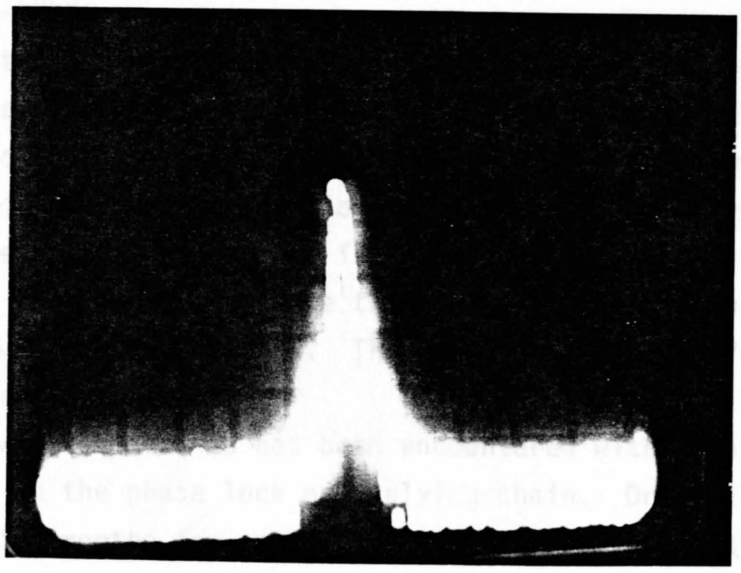


Figure 2. Photograph of 750 MHz IF Output of Klystron Phase Lock, Same Scales as Figure 1.

The receiver and phase lock mixers mentioned as problems in the last report were ordered from Hughes because of their promised 45-60 day delivery date. Furthermore, good results with the Hughes mixers contacted at EES have lately been obtained, with noise figures of ~ 10 dB DSB at 94 GHz being measured. This performance is expected to improve to 7-8 dB with the addition of IF matching networks which are now being designed.

PLANS FOR NEXT PERIOD

The klystron phase locking circuitry will be cleaned up by shortening cables and improving grounding in an attempt to obtain a better phase lock. Work has begun on mechanical layout and cable and connector selection which will be continued. Work will also begin on the three additional Henry circuits which will be required for the total system.

PROBLEMS ENCOUNTERED

An unexpected peturbation in the antenna subsystem was encountered when it was determined that rectangular to circular waveguide transitions will be required for all five antennas ordered from TRG. Previously, it had been assumed that these transitions were part of the antenna feed. The price of these five transitions is $2550, which overruns the Unit 5 budget by about this amount, because this budget was approximately even before these devices were ordered. This change will not affect the TRG estimated delivery dates.

A problem with deliveries has been encountered with Avantek for the amplifiers used in the phase lock multiplying chain. Originally, they had estimated five months for one of the amplifiers and 90 days for two others. The five month problem was relieved by ordering that particular amplifier from Miteq, but an improved delivery data could not be negotiated for the other two amplifiers. As mentioned in earlier reports, these long deliveries will probably cut into system testing time.

Cost Information

The following charges have been incurred against the contract during the period 1 May to 31 May 1979.

Personal Services (PS)	$ 8,631.44
Materials and Supplies	99,291.31
Travel	0.00
Overhead (@ 76% of PS)	6,559.90
Retirement (@ 9.83% of PS)	741.21
TOTAL	$115,223.86

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 315.65	15
Senior Research Engineers	1,930.90	116
Research Engineers	2,252.33	225
Assistant Research Engineers	1,945.61	219
Student Assistants	1,090.98	247
Technicians, Machinists	1,068.53	144
Clerical	27.44	6
TOTAL	$8,631.44	972

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$156,065.98	$ 59,969.40	$ 96,096.58
Materials and Supplies	248,151.34	232,092.85	16,058.49
Travel	2,698.00	372.67	2,325.33
Computer	400.00	0.00	400.00
Overhead	118,610.50	45,501.16	73,109.34
Retirement	15,341.18	4,892.28	10,448.90
AS PROPOSED	$541,267.00	$342,828.36	$198,438.64

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 38% of the proposed task has been completed, based on personal services expended to date.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 13 of 18

1 June 1979 through 30 June 1979

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-0-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

July 10, 1979

WORK PERFORMED DURING THIS PERIOD

The klystron phase lock circuitry has been greatly improved by adjusting signal levels to give improved AGC and discriminator performance. The RF layout was also changed to shorten leads and reduce power supply lead clutter. These changes resulted in a locking range for the phase lock of 200 volts as measured by the power supply reflector voltage meter. This measurement was made by first adjusting the reflector voltage until the klystron was locked, and then varying the reflector voltage control in both directions until the lock was broken. The range over which the voltage could be varied was 200 volts as noted above.

The pull-in range for the frequency discriminator circuit is still not as large as desired. Ideally, this range should equal the above-mentioned locking range, or the electronic tuning range of the tube, whichever is less. Measurements indicate that this range is about 80 - 100 V. Circuit modifications to improve this range are being considered.

The recovery time of the phase lock system has been measured. The klystron was first phase locked by adjusting its reflector voltage. The reflector was then 100% modulated by the internal power supply 2 kHz square wave such that one extreme of the square wave voltage turned the tube off and the other extreme placed the reflector within the discriminator pull-in range. Figure 1 is a photograph of the resulting modulated power output of the klystron. This picture shows that the tube locks about midway through the negative half-cycle of the square wave, as indicated by the flat portion of this half-cycle. It was determined that the tube is locked during this time by varying the reflector voltage and noting that the power level does not change. Locking time, as shown on the trace, is slightly over 200 μsec, although the tube sometimes locks in less time, as indicated by the double trace.

Figure 1 also shows the turn-off time of the klystron, and indicates that it will probably be longer than the required minimum of about 0.5 μs. Part of this turn-off time can be attributed to the slow rise time of the

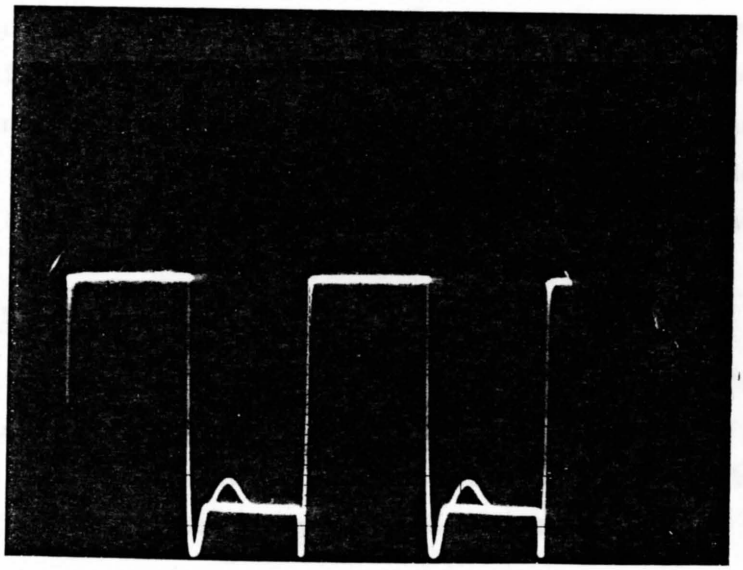


Figure 1. Phase locked klystron power output in response to square wave modulation, 200 μs/div, 20 mV/div.

internal power supply modulator, so that definitive measurement of turn-off time must await installation of the transistor switch which will drive the reflector directly.

The modulator for the 140 GHz EIO has been tested into a dummy load, and voltage swing levels adequate for this tube (~8 kV) were measured. There is excessive fluctuation on this level, however, that will not affect operation of the 140 GHz system, but may cause problems with locking the 94 GHz tube if it also appears on that modulator. Delivery of the higher voltage tube and power supply for the 94 GHz system are expected in about one week. The driver circuit for these modulators is considered sufficiently finalized that work is proceeding on circuit board layout.

PLANS FOR NEXT PERIOD

Circuit changes will be made to improve the phase lock discriminator pull-in range. The 94 GHz klystron reflector switch will also be installed and tested. It is expected that at least one of the modulator circuits will be available for system integration during this time.

PROBLEMS ENCOUNTERED

The Hughes Gunn oscillator is displaying erratic behavior. When thoroughly warmed up and adjusted for the center of its locking range, it will remain locked for extended periods of time - about 12 hours straight in one instance. However, from a cold start, some adjustment is required to cause the device to oscillate, and the erratic output persists until complete thermal equilibrium is achieved.

Hughes was contacted about this problem, and Joe Cadwalader, their phase lock expert, determined that the source is oscillating on the lower sideband, which is 200 MHz low in frequency, and suggested that we return it for adjustment. Accordingly, it was returned to Hughes and is expected to be repaired and sent back to Georgia Tech early in the week of 23 July.

The Clare Signalite 90-140 GHz noise source delivery is being delayed from early August to late September because of late deliveries from their suppliers. It is possible that a noise source available at Georgia Tech can be used to test the noise figure test facility to avoid late delivery of this facility to MIRADCOM.

TRG has informed us that several waveguide components, including attennuators, wavemeters, and couplers, will be slipped in delivery date from 1 September to 5 October. These parts are primarily for the 140 GHz transmitter/receiver, and will therefore cause the delivery of that system to slip beyond the 19 October contract expiration date.

Cost Information

The following charges have been incurred against the contract during the period 1 June to 30 June 1979.

Personal Services (PS)	9,182.92
Materials and Supplies	33,727.25
Travel	0.00
Overhead (@ 76% of PS)	6,979.02
Retirement (@ 9.83% of PS)	719.07
TOTAL	50,608.26

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	700.31	35
Senior Research Engineers	2,336.88	152
Research Engineers	3,271.23	268
Assistant Research Engineers	930.60	95
Student Assistants	1,087.10	263
Technicians, Machinists	583.72	74
Clerical	273.08	52
TOTAL	9,182.92	939

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	142,366	68,207.38	74,158.62
Materials and Supplies	274,010	265,820.10	8,189.90
Travel	2,698	372.67	2,325.33
Computer	0	0.00	0.00
Overhead	108,198	51,837.62	56,360.38
Retirement	13,995	5,522.99	8,472.01
AS PROPOSED	541,267	391,760.76	149,506.24

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 48% of the proposed task has been completed. Note that the funds have been slightly reallocated since the last report.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 14 of 18

1 July 1979 through 31 July 1979

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

August 15, 1979

WORK PERFORMED DURING THIS PERIOD

Since the 94 GHz Gunn oscillator has been returned to Hughes for repair, attempts have been made to phase lock the 94 GHz injection locking klystron to a harmonic of a stable low frequency source. The first approach involved the use of a Hewlett-Packard sweeper locked to a frequency standard. Unfortunately, it was not possible to lock this sweeper by using available phase locking components. An attempt is currently being made to lock the 94 GHz klystron to a phase-locked 10 GHz klystron. This work has application to the overall system design because the frequency translator and phase lock loop synchronizer will both be locked to harmonics of a 3.6 GHz source. Hughes estimates that the 93.25 GHz Gunn oscillator will be shipped on 14 August.

Several low-pass filters with a cut-off frequency of 150 MHz have been received. These filters were bought at the suggestion of Paul Henry to keep higher frequency RF power from the discriminator and phase output circuits, and will be evaluated when the Hughes Gunn is returned.

The stainless steel stock for the corner reflector mandrel has been received, and machining of this mandrel will begin shortly. Also, two more mixers have been contacted - one each in F-band and W-band. The high voltage modulator tube for the 94 GHz system has not yet been shipped, but according to Werner Brunhart of Eimac, it will be shipped as soon as it can be characterized.

PLANS FOR NEXT PERIOD

The Hughes Gunn oscillator will be re-integrated into the system and circuit changes, including the 150 MHz filters, will be made to improve the pull-in range. If the modulator tube is received soon, the modulator for the 94 GHz system may be ready for testing.

PROBLEMS ENCOUNTERED

The longer-than-expected delay of the return of the Hughes Gunn oscillator makes meaningful work on the electronic circuits very difficult.

Cost Information

The following charges have been incurred against the contract during the period 1 July to 31 July 1979

Personal Services (PS)	$ 10,745.03
Materials and Supplies	15,180.06
Travel	344.00
Overhead (@ 76% of PS)	8,166.23
Retirement (@ 9.83% of PS)	1,008.60
TOTAL	$ 35,443.92

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 2,279.54	114
Senior Research Engineers	3,334.76	217
Research Engineers	2,943.99	241
Assistant Research Engineers	0.00	0
Student Assistants	1,924.43	465
Technicians, Machinists	0.00	0
Clerical	262.31	50
TOTAL	$ 10,745.03	1087

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 142,366	$ 79,897.35	$ 62,468.65
Materials and Supplies	274,010	281,000.16	-6,990.16
Travel	2,698	716.67	1,981.33
Computer	-	0.00	0.00
Overhead	108,198	60,646.41	47,551.59
Retirement	13,995	6,619.95	7,375.05
AS PROPOSED	$ 541,267	$ 428,880.54	$ 112,386.46

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 56% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 15 of 18

1 August 1979 through 31 August 1979

MILLIMETER GUIDANCE
TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for

U. S. Army Missile Research and Development Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

September 12, 1979

WORK PERFORMED DURING THIS PERIOD

The Hughes Gunn oscillator was received and has been re-integrated into the system. This oscillator worked very well at first, but has lately required some time to lockup, although it is usually stable when it finally does lock. Locking times range up to two hours for this device.

George Ziff of Hughes was contacted about this problem and he asked us to use the device as is until he and Joe Cadwallader can look at it when they come to Georgia Tech early next month. In the meantime, we are changing the waveguide configuration to ensure that there is no possibility of a mismatch, since a small mismatch would cause locking difficulty in this oscillator.

Mismatch problems were found to be the cause of the discrimination pull-in problems in the klystron phase lock circuit. When mismatched, the output of the klystron has strong sidebands spaced 7-8 MHz away from the main output, and the phase lock system was locking on one of these sidebands. By placing an E-H tuner on the klystron output, it was possible to minimize these sidebands in such a way that the tube would pull into lock from any frequency on its mode. This additional matching was necessary even though the tube output went directly into an isolator, after passing through a 20 dB coupler.

A 94 GHz klystron for the frequency translation system has been received. This tube has a mechanical tuning range of 6 GHz and its power output ranges from 250 mW at 91 GHz to 550 mW at 97 GHz. The two 140 GHz tubes are scheduled to be shipped later this month.

The Eimac Z2172F modulator tube for the 94 GHz system has finally been received. It is expected that the modulator will be available for integration into the system during the next reporting period.

PLANS FOR NEXT PERIOD

Hopefully, the Gunn oscillator phase lock problems will be solved during the next period, and the EIO subsystem will be available for

integration into the system. A large number of drawings will be released to the shop for fabrication of brackets, chassis, etc. for both the 94 and 140 GHz systems.

PROBLEMS ENCOUNTERED

In addition to the ever-present procurement problems, the erratic behavior of the Hughes Gunn oscillator is also a problem.

Cost Information

The following charges have been incurred against the contract during the period 1 August to 31 August 1979

Personal Services (PS)	$ 8,326.08
Materials and Supplies	-4,754.00
Travel	24.80
Overhead (@ 76% of PS)	6,327.82
Retirement (@ 9.83% of PS)	616.31
TOTAL	$10,541.01

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 518.08	26
Senior Research Engineers	2,453.80	160
Research Engineers	2,142.04	175
Assistant Research Engineers	571.70	53
Student Assistants	2,448.47	592
Technicians, Machinists	105.92	14
Clerical	86.07	16
TOTAL	$8,326.08	

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$142,366	$ 88,223.43	$ 54,142.57
Materials and Supplies	274,010	276,245.16	-2,236.16
Travel	2,698	741.47	1,956.53
Computer	-	0.00	0.00
Overhead	108,198	66,974.23	41,223.77
Retirement	13,995	7,236.26	6,758.74
AS PROPOSED	$541.267	$439,421.55	$101,845.45

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 62% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 16 of 20

1 September 1979 through 30 September 1979

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for

U. S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

October 19, 1979

WORK PERFORMED DURING THIS PERIOD

The Hughes 94 GHz Gunn oscillator has failed again and has been returned for repair. George Ziff of Hughes promises a quick turnaround this time. To keep the 94 GHz injection-locking klystron available for use and to continue testing the phase lock circuitry, this tube has been locked to a phase locked x-band klystron, so that it is not essential for continued system tests that the Gunn be returned immediately. Perhaps it would be well to give Hughes enough time so that they can assure us that the Gunn will perform to expectation instead of strenuously insisting that this oscillator be repaired and returned immediately.

Work on the EIO modulator is still being held up pending delivery of the 25 kV power supply, but the delay has been used to some advantage by making some improvements in the modulator pulse shaping circuitry. The old system of summing four different waveforms to effect a flat modulator drive pulse has been replaced by an approach in which the pulse is divided into an integral number of 20 ns increments, which are individually controllable in amplitude. The pulse flatness and initial changing spike are then implemented by varying the relative amplitudes of these increments. Tests have shown that this method results in ripple as low as 30 V PP superimposed on a pulse of 8 kV amplitude.

The mandrel for electroforming of the corner cube reflectors is finished. Final machining is complete and the device has been polished. Polishing is necessary both to give the corner reflectors a good finish and to allow for easy separation of the mandrel and the electroformed part. It is noted that the polishing operation resulted in a slight rounding of the sharp edges on the corners. Methods of correcting this problem are being investigated.

On October 8, a visit was made to Contraves Goerz in Pittsburgh by R. W. McMillan to check into the possibility of using a small periscope mount which they have built for AVCO on the 220 GHz radar program recently initiated for Night Vision Laboratory. While at Contraves, some tests were witnessed on a tracker mount almost identical to that on order for the Millimeter Guidance Technology Hardware Program. Our mount is not yet in the testing phase but is expected to be ready for shipment in mid-November.

The question of tracking accuracy was discussed with Bob Grimes, Stan Synder, and Al Byers of Contraves. It appears that our tracker mount will be able to track targets to an accuracy equal to the overall mount accuracy (0.01 degrees) in spite of the fact that the resolvers used for azimuth and elevation readout are accurate to only 0.05 degrees. The reason for this seeming discrepancy is that the resolver errors are not random errors; they are repeatable errors which repeat to an accuracy of 0.01 degrees, so that in a closed loop system, tracking to this accuracy will be possible. It should be noted, however, that the accuracy of the digital azimuth and elevation angle readouts are only 0.05 degrees, even though the displays will read to an accuracy of 0.01 degrees. During this visit to Contraves, the transfer functions, necessary for closing the tracker loop for the mount were obtained from Al Byers, who also spent some time explaining the mount status outputs. These outputs give the status of the mount with regard to stow functions, azimuth and elevation rate trip, etc. Apparently it will be necessary for EES to build a status panel and associated cabling for these functions.

PLANS FOR NEXT PERIOD

The mandrel will be shipped to KHI Electroform in Orlando, Florida for fabrication of the corner reflectors. The high voltage power supply for the EIO modulator should be received by mid-October and the modulator can hopefully be ready for testing during the next reporting period. The availability of the modulator is the key to further testing of the 94 GHz system, because the next critically important steps in the testing of this system are the testing of the phase and injection-locking approaches for the EIO.

PROBLEMS ENCOUNTERED

The Hughes Gunn oscillator has failed again, as noted above. There is also a continuing problem with deliveries of critical parts from various manufacturers. The modulator power supply mentioned above is one example.

Baytron, Inc. has also been extremely slow with their shipments. Couplers and detectors ordered from them over one year ago have not yet been delivered. These devices have not yet been needed because of delays in other areas, but will become of critical importance as the systems are assembled for testing.

TRG has shipped antennas and polarizers with the wrong flanges on three separate occasions. The horn-lens antennas were shipped with rectangular instead of circular waveguide inputs. The 140 GHz 12 inch cassegrain antenna and the 140 GHz rectangular to circular transistions were both shipped with UG-387 flanges instead of FXR flanges. The two 140 GHZ klystrons from Varian arrived with WR-6 instead of the specified WR-8 waveguide outputs. These problems are being worked out with these vendors, but the required corrections will cause unavoidable delays.

Cost Information

The following charges have been incurred against the contract during the period 1 September to 30 September 1979.

Personal Services (PS)	$10,925.06
Materials and Supplies	-1,477.19
Travel	0.00
Overhead (@ 76% of PS)	8,303.04
Retirement (@10.51% of PS)	920.02
TOTAL	$18,670.93

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 1,726.93	81
Senior Research Engineers	2,243.05	128
Research Engineers	1,316.71	98
Assistant Research Engineers	1,827.63	168
Student Assistants	2,171.50	409
Technicians, Machinists	1,553.17	179
Clerical	86.07	15
TOTAL	$10,925.06	1,078

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$142,366	$ 99,148.49	$43,217.51
Materials and Supplies	274,010	274,768.97	- 758.97
Travel	2,698	741.47	1,956.53
Computer	0	0.00	0.00
Overhead	108,198	75,277.27	32,920.73
Retirement	13,995	8,156.28	5,838.72
AS PROPOSED	$541,267	$458,092.48	$83,174.52

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 70% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 17 of 20

1 October 1979 through 31 October 1979

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for

U. S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

November 19, 1979

WORK PERFORMED DURING THIS PERIOD

The noise figure test facility is essentially complete. The only test of this facility yet to be made is the testing of an actual mixer with the Clare noise tube at 94 GHz. The system has already been tested with an IF noise source. A feature of this facility is that it has local oscillators of both 780 MHz and 1-2 GHz, which are used specifically for testing the 750 MHz IF components of the remaining units and those of any other 1-2 GHz IF system, respectively.

As stated in the last report, the electroform mandrel to be used for fabricating the corner cubes has been machined and polished. However, it was noted that the polishing operation resulted in corners that were somewhat rounded, with a potential for degraded performance. Because of these rounded corners, it was decided to make another cut on each face of the mandrel, thus restoring the corners; and to polish the faces again using a technique designed to essentially eliminate rounding. The machine cuts on this part are currently being made.

Several components have recently been received. The tripod mounts for the 94 and 140 GHz systems, most of the parts for the multiplying chains, and mixers from Hughes are among the parts recently received. The multiplying chains could be tested completely if one or two key parts in each chain were available.

The 140 GHz EIO has been tested by using the tube belonging to this program and power supplies belonging to the Harry Diamond Laboratories Mobile Measurements Facility. Frequency and power measurements are currently being made.

A 140 GHz feed horn for use with the 94 GHz conscan antenna is being designed. This horn will be fabricated by KHI Electroform in Orlando, Florida when the design is complete. Also, a circuit for synchronization of the transmitter pulses with the conical scan has been designed. This circuit will use a thumbwheel switch whose readout is a direct indication of the number of pulses per conical scan cycle. Furthermore, a phase control circuit will be provided which allows variable delay of the transmitter pulses so that they can be moved in angle relative to the conical scan angle. This feature assures that pulses may be adjusted to occur at any conscan angle.

PROBLEMS ENCOUNTERED

Deliveries of key components continue to be a problem. TRG has promised that all of their outstanding parts still owed us will be shipped by 30 December. Baytron has given us a date of 30 November for shipment of their components to us. The modulator power supplies are scheduled to be shipped on 15 November. These shipping dates represent delays of up to six months for some TRG components and over one year for a few of the Baytron components. In addition, the modulator power supplies are three months overdue. These late deliveries leave little time for proper methodical testing of the individual systems before delivery.

PLANS FOR NEXT PERIOD

The second iteration of mandrel machining will be completed, and the electroforming of corner cubes will begin. The noise figure test facility will be delivered, and the multiplying chain for the frequency translator and phase lock will be tested. The modulator power supplies should be received, so that fabrication and testing of the 94 GHz modulator can be completed. The Contraves Goerz tracker mount is also due during the next reporting period.

Cost Information

The following charges have been incurred against the contract during the period 1 October to 31 October 1979.

Personal Services (PS)	$11,012.60
Materials and Supplies	1,667.40
Travel	121.62
Overhead (@ 76% of PS)	8,369.57
Retirement (@10.51% of PS)	763.88
TOTAL	$21,935.07

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 518.08	24
Senior Research Engineers	728.07	41
Research Engineers	3,198.61	239
Assistant Research Engineers	574.20	53
Student Assistants	3,170.08	597
Technicians, Machinists	2,733.75	315
Clerical	89.81	15
TOTAL	$11,012.60	1,284

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$142,366	$110,161.09	$32,204.91
Materials and Supplies	274,010	276,436.37	-2,426.37
Travel	2,698	863.09	1,834.91
Computer	0	0.00	0.00
Overhead	108,198	83,646.84	24,551.16
Retirement	13,995	8,920.16	5,074.84
AS PROPOSED	$541,267	$480,027.55	$61,239.45

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 77% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 18 of 20

1 November 1979 through 30 November 1979

MILLIMETER GUIDANCE
TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for

U. S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

December 19, 1979

WORK PERFORMED DURING THIS PERIOD

The multiplier chain which will be used for both the frequency translator and the phase lock systems has been tested. A signal with power level 0 dBm and frequency 10 MHz was put into this chain and 3.42 GHz at 10 dBm was observed on the output. The input and output spectra and power levels of this device are 9.25-13 MHz, 0 dBm and 3392-3808 MHz, 10 dBm, respectively. This output will be harmonically mixed with the klystron output to generate an IF for phase locking. The frequency translator multiplier differs slightly from the above in that its input signal spectrum is 424-476 MHz, 0 dBm for the same output as that given above.

A video line driver which will be used to drive the cable between the 94/140 GHz system and the van has been built and tested. Figure 1 shows the response of this amplifier to a 50 ns pulse.

The machining of the corner cube mandrel is complete. Each of the three faces of this mandrel was machined separately by using a special fixture together with a large lathe available in the Georgia Tech machine shop. The corners are square and the surfaces are flat to within the measurement capabilities of the machine shop. The mandrel has been sent to KHI Electroform in Longwood, Florida for final polishing and forming of the corner cubes. The first reflectors should be available early in January.

The three additional klystrons recently received (1-94 GHz, 2-140 GHz) have been tested. The 94 GHz tube appears to be slightly noisy, but further measurements are required to determine if this tube can be phase locked, which will determine whether it is suitable for use in the frequency translator. An attempt is currently being made to lock this tube to the multiplier chain.

The manual for the noise figure test facility has been written and a rough draft has been typed. After inclusion of some corrections in the manual, the noise figure facility can be delivered, probably by 21 December.

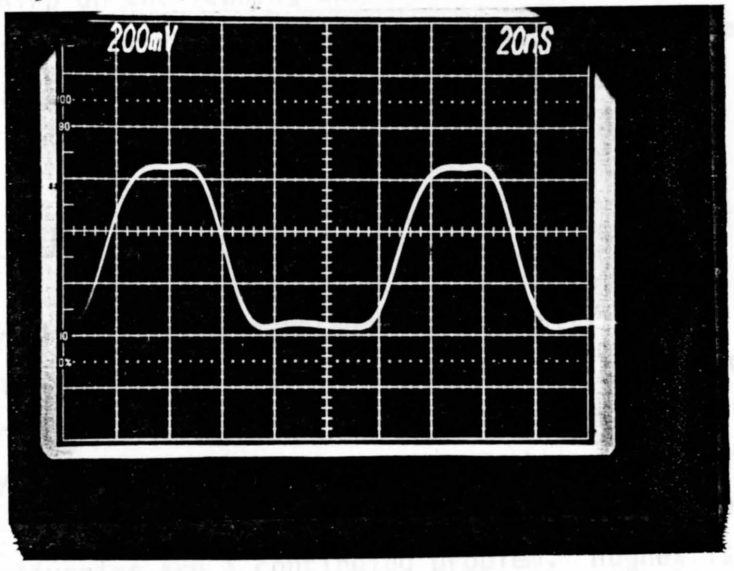


Figure 1. Response of video line driver to 50 ns input pulse.

Careful adjustment of the 140 GHz EIO pulse shaping circuitry has resulted in a frequency shift on the flat part of the pulse which is almost undiscernible when using a wavemeter to test the spectrum. This means that the wavemeter resonance causes a uniform displacement of the flat part of the pulse when tuned through the EIO output. There is, of course, some chirp on the leading and trailing edges of the pulse. Although less important for the 140 GHz system, the relatively clean spectrum indicated by this test is necessary for successful locking of the 94 GHz EIO.

PROBLEMS ENCOUNTERED

The noisy klystron mentioned above may be difficult to lock. Also, the multiplying chain which begins at 9-13 MHz may be difficult to use as a locking reference because of accumulated noise inherent in multiplying by such a large number. Both of these questions will be answered when an attempt is made to lock the tube to this multiplier.

Vendor deliveries are a continuing problem. Hughes is having difficulty in meeting the 10 dBm power requirement on the 94 GHz Gunn oscillator, so that return of this device to Georgia Tech is delayed.

PLANS FOR NEXT PERIOD

Klystrons will be locked to the multiplying chain, and corner cubes will be received. Emphasis will be placed on the 140 GHz system, since it has the best chance of being delivered on schedule.

Cost Information

The following charges have been incurred against the contract during the period 1 November to 30 November 1979.

Personal Services (PS)	$10,564.98
Materials and Supplies	1,480.11
Travel	171.29
Overhead (@ 76% of PS)	8,029.39
Retirement (@10.51% of PS)	936.49
TOTAL	$21,182.26

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 690.77	32
Senior Research Engineers	1,413.67	80
Research Engineers	5,098.46	381
Assistant Research Engineers	0.00	0
Student Assistants	1,704.55	321
Technicians, Machinists	1,567.72	181
Clerical	89.81	15
TOTAL	$10,564.98	1,010

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$142,366	$120,726.07	$21,639.93
Materials and Supplies	274,010	277,916.48	-3,906.48
Travel	2,698	1,034.38	1,663.62
Computer	0	0.00	0.00
Overhead	108,198	91,676.23	16,521.77
Retirement	13,995	9,856.65	4,138.35
AS PROPOSED	$541,267	$501,209.81	$40,057.19

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 85% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 19 of 20

1 December 1979 through 31 December 1979

MILLIMETER GUIDANCE
TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared For
U.S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

January 17, 1980

WORK PERFORMED DURING THIS PERIOD

Two different 94 GHz klystrons have been successfully locked to the multiplying chain using the Hewlett-Packard 8640B oscillator operating in the range 424-476 MHz as an input. One of these tubes was also locked with an input of 104 MHz, but the lock becomes progressively poorer as the input frequency to the multiplying chain is reduced because of noise build up in the amplifiers and doublers. Due to this noise problem, it will be necessary to replace the part of the frequency translator multiplier chain that goes from 10 MHz to 450 MHz with a phase locked UHF source. The phase lock multiplying chain (Unit 8) is unaffected because its reference input is in the range 424-450 MHz.

One of the 94 GHz tubes that was locked to the multiplying chain is the tube that was described as noisy in the last monthly report. This tube is apparently acceptable. The phase lock system for Unit 8 is being assembled and has been successfully tested with a 94 GHz tube. This system requires minor modifications to improve its locking capability. It is expected that this unit will be finished by 19 February. Neither of the 140 GHz tubes have been locked because they are being used for antenna pattern measurements. One of these tubes will be locked when these measurements are completed.

The corner cube mandrel has been delivered to KHI electroform, and one large (200 m^2 at 94 GHz) cube has been formed and shipped to Georgia Tech. This reflector is expected during the third week in January. A second cube is currently being formed, and additional devices are expected at intervals of 1-2 weeks.

The Contraves tracker mount has been received. This mount will be tested when the instruction manual has been received from Al Bowers of Contraves. Several additional key components are still lacking, including power supplies from Bertan, ferrite switches from TRG, and detectors from Baytron.

The Noise Figure Test Facility manual has been finished, but unfortunately the Clare-Signalite noise tube has failed. This tube has

been returned for repair, but it appears that at least two weeks will be required for return of this device. Delivery of Unit 3 will therefore be delayed until the noise tube is returned.

The 140 GHz modulator will be delivered by the EES Radar Laboratory during the third week in January. The base plate and the rest of the mechanical package are also essentially finished and should also be delivered during this time. The 140 GHz system can then be assembled with the exception of several key components yet to be received.

Antenna pattern measurements are being made on the 12 inch 140 GHz antenna and the 24 inch conscan with a 140 GHz feed. It has been necessary to devise some new techniques for these measurements because the Scientific-Atlanta pattern measuring equipment is not designed for such high frequencies. It is expected that these measurements will be completed during the next reporting period.

PROBLEMS ENCOUNTERED

It appears that the Hughes Gunn oscillator will not be delivered until about 15 February because of delays that they are experiencing in obtaining Gunn devices. Steve Gekko of Hughes assures us that this oscillator will be reliable because of improved semiconductor mounting techniques. Late deliveries from Bertan, TRG, and Baytron continue to be a problem. It will be necessary to replace part of the frequency translator multiplying chain with a phase locked 450 MHz source to eliminate most of the noise inherent in multiplying from a 10 MHz source.

PLANS FOR NEXT PERIOD

The repaired Clare-Signalite noise source will be returned to Georgia Tech so that the Noise Figure Test Facility can be delivered. The phase lock system (Unit 8) is also expected to be completed and most of the work on the 140 GHz system, assuming that several critical items are received, will also be complete. Antenna pattern measurements should be finished and corner cube cross section measurements will begin.

Cost Information

The following charges have been incurred against the contract during the period 1 December to 31 December 1979.

Personal Services (PS)	11,107.05
Materials and Supplies	604.43
Travel	258.00
Overhead (@ 76% of PS)	8,441.36
Retirement (@10.51% of PS)	899.74
TOTAL	21,310.58

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	345.39	16
Senior Research Engineers	1,396.47	79
Research Engineers	4,273.49	319
Assistant Research Engineers	31.42	3
Student Assistants	2,546.25	480
Technicians, Machinists	2,464.83	284
Clerical	49.20	8
TOTAL	11,107.05	1189

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	142,366	131,833.12	10,532.88
Materials and Supplies	274,010	278,520.91	-4,510.91
Travel	2,698	1,292.38	1,405.62
Computer	00	0.00	0.00
Overhead	108,198	100,117.59	8,080.41
Retirement	13,995	10,756.39	3,238.61
AS PROPOSED	541,267	522,520.39	18,746.61

Additional funds have been requested to complete this task. Aproximately 88% of the proposed task has been completed.

A1 - A166

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 20

1 January 1980 through 31 January 1980

MILLIMETER GUIDANCE
TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for
U.S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

February 14, 1980

WORK PERFORMED DURING THIS PERIOD

The 140 GHz modulator is complete. Figure 1 is a photograph of this device showing the actual modulator which will be mounted in the 140 GHz system chassis. The control panel and power supplies which will be rack mounted in the van or in another suitable place are not shown in this picture. Figure 2 shows the modulator voltage, EIO collector current, and EIO rf output pulse, from top to bottom. The rf pulse varies so little in frequency that this variation cannot be detected by tuning a wavemeter resonance through the pulse. All of the pulse varies uniformly in amplitude as the resonance is tuned through. The Q of this wavemeter is about 3000 based on 94 GHz measurements, indicating that the intrapulse frequency variation of the EIO rf output is possibly on the order of 10 - 20 MHz.

The phase lock system (Unit 8) is expected to be completed by the current delivery date (February 19). At that time, both the phase lock and the noise figure test facility will be delivered. A slight problem with 750 MHz balanced mixer offset in the phase lock has been corrected, which improved the locking range of the circuit. At the present time, the 94 GHz klystron will remain locked when the power supply reflector is varied over a range of 170 volts.

The Contraves tracker mount has been set up and initially checked. The instruction manual and a 110-foot length of control cable have not yet been received. A tracker mount status panel is being built here at Georgia Tech.

The 90-140 GHz noise tube which was returned to Clare-Signalite for repair will be shipped on February 15. This device failed because of a metal obstruction in the waveguide.

A total of six corner cube reflectors have been received, and work has begun on calibrating them. Flat plate calibration standards are being made in three different sizes which will be used with spheres or cylinders, where available, to calibrate the reflectors. It is important that standards having cross sections of about the same magnitudes as the devices to be measured be used because signal levels will be similar, and instrumental errors will tend to cancel. The

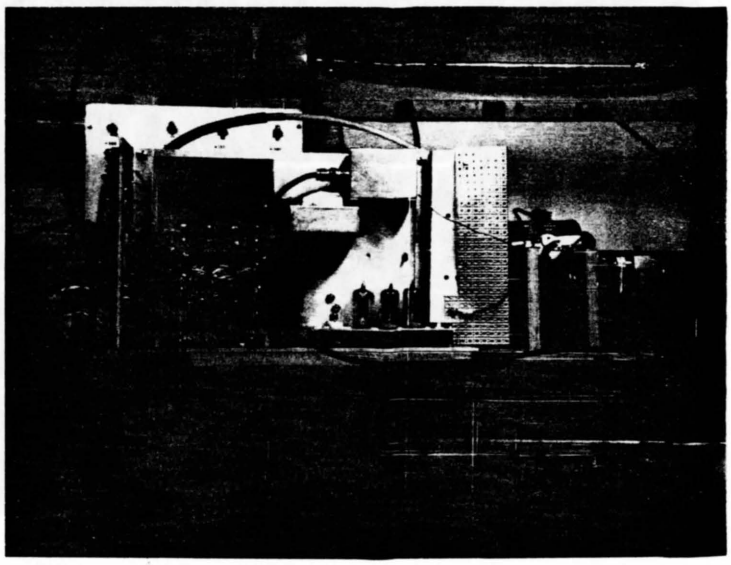


Figure 1. Photograph of 140 GHz EIO modulator. The EIO is shown on the right side of the picture.

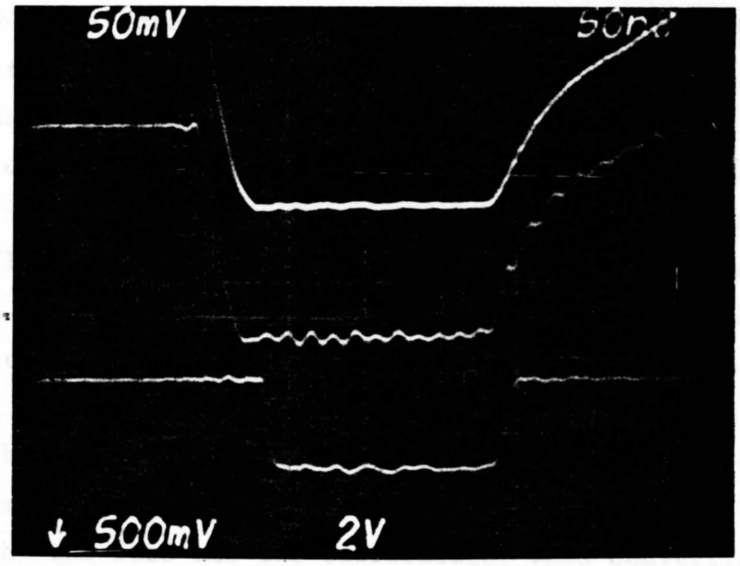


Figure 2. Cathode drive voltage, collector current, and rf output pulse at 2000 V/cm, 100 mA/cm, and 50 mV/cm, respectively. The sweep time is 50 ns/cm.

corner cubes are being mounted to aluminum cylinders by using epoxy. These cylinders are drilled and tapped for a standard 1/4"-20 tripod screw, and care is taken to assure that the cylinders are in the shadow of the reflector itself, so that there is no chance for the cylinders to modify the cross section.

The radiation pattern of the 12-inch TRG 140 GHz antenna has been measured. Azimuth and elevation profiles of this antenna are shown in Figures 3 and 4, respectively. It will be recalled that TRG would not measure the patterns of antennas at 140 GHz unless we furnished them a source.

The 94 GHz conscan antenna was modified for 140 GHz operation by replacing the feed with an available WR-8 horn. As anticipated, the conscan crossover occurred at 6dB instead of the required 3dB. The feed was then defocussed to give a 3dB crossover, but this change increased the beamwidth. Although the antenna would work in this mode, there would be little advantage of the 140 GHz system over the 94 GHz system as regards multipath, because of this increase in beamwidth. It was then concluded that it will be necessary to machine a new subreflector which will be radially displaced from the antenna axis by an amount different than for the 94 GHz subreflector, resulting in a 3dB crossover without compromising antenna beamwidth. It will then be necessary to change both the feed and the subreflector when converting this antenna from 94 to 140 GHz.

A phase locked source multiplying chain for the frequency translator has been ordered, which will use a nominal 112 MHz 0dBm signal as a reference and will have an output of 3.7 to 4.2 GHz at 13dBm. The 112 MHz signal will be generated by multiplying a nominal 11.25 MHz output from the frequency synthesizer by 4 and mixing it with a 67 MHz crystal oscillator. Fabrication of this multiplying chain has been a problem because of the difficulty of multiplying from 11.25 MHz to 3.6 GHz without excessive noise build up.

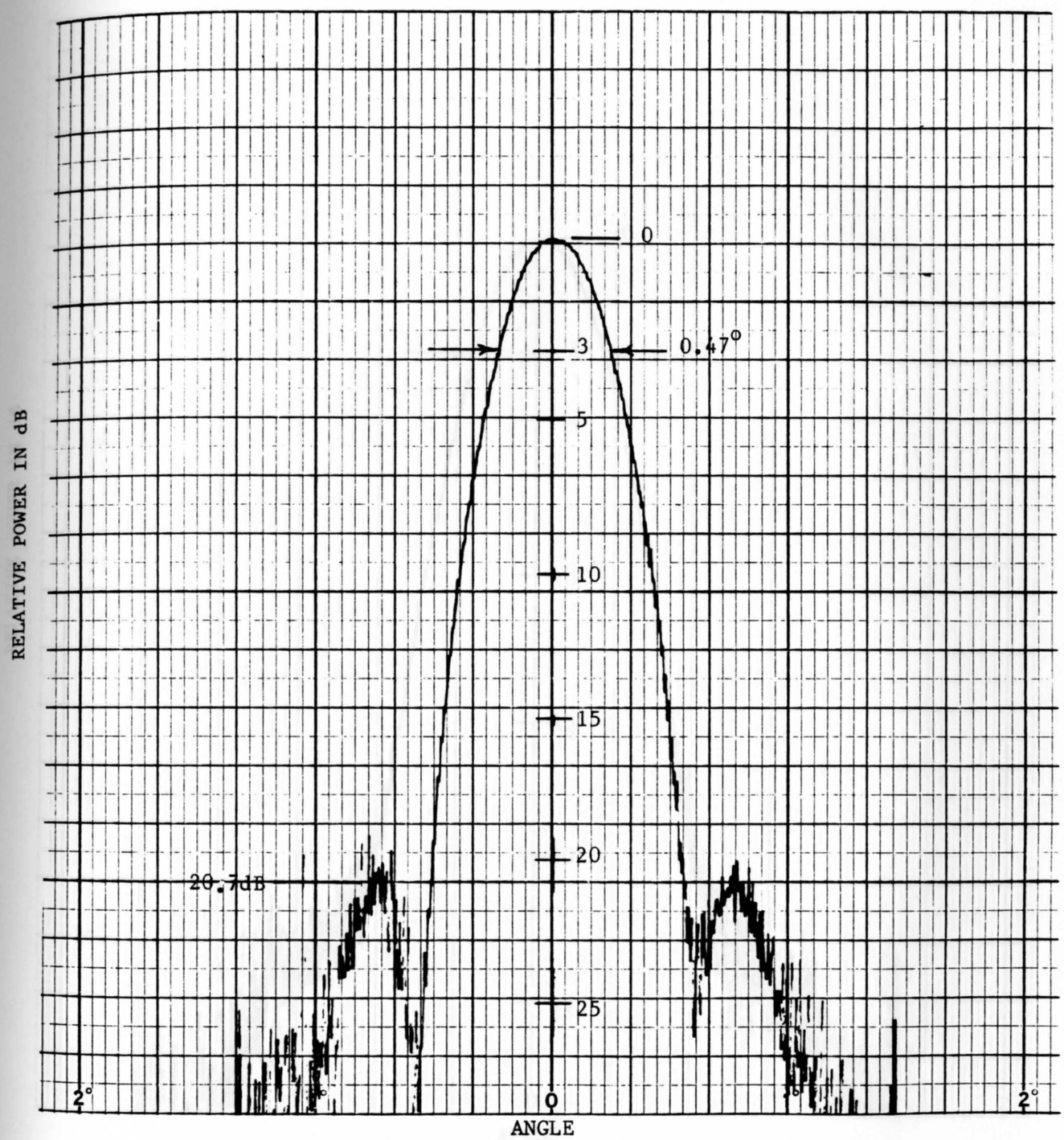


Figure 3. H-plane (azimuth) radiation pattern of the F-band 12 inch antenna measured at 139 GHz.

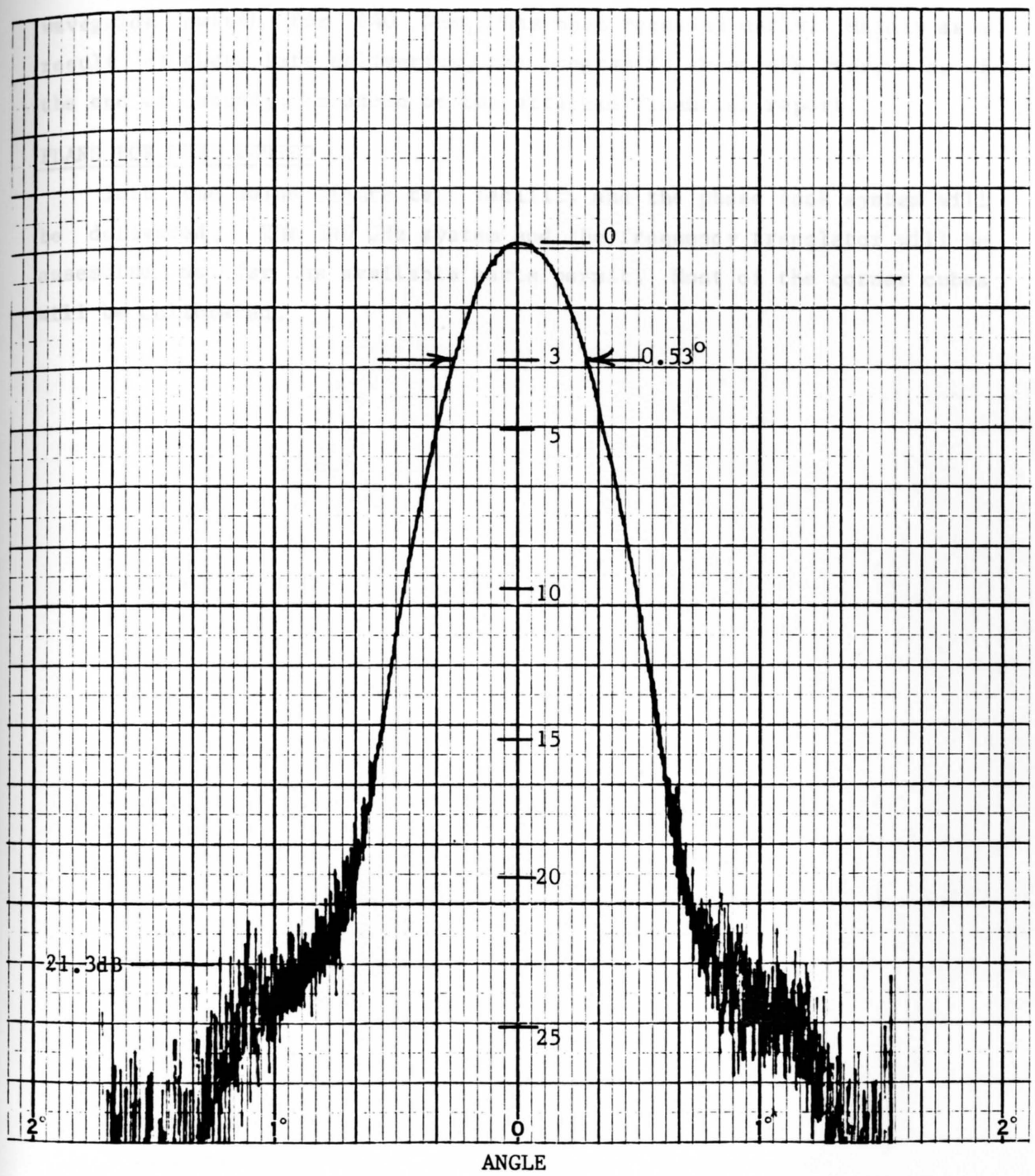


Figure 4. E-Plane (elevation) radiation pattern of the F-band 12 inch antenna measured at 139 GHz.

PROBLEMS ENCOUNTERED

Delivery dates for the final few remaining critical TRG components have been revised to 29 February, although one of these devices, a waveguide switch for 140 GHz, has been received early. Mainly as a result of these late deliveries, the program is about $9K overrun as of the end of January, as shown on the attached financial report.

PLANS FOR NEXT PERIOD

Both the noise figure test facility and the phase lock system will be delivered. The 140 GHz system and the frequency translator will be assembled as far as available parts permit. Most of the corner cubes will be calibrated.

Cost Information

The following charges have been incurred against the contract during the period 1 January to 31 January 1980.

Personal Services (PS)	$12,019.86
Materials and Supplies	5,531.46
Travel	497.08
Overhead (@ 76% of PS)	9,135.09
Retirement (@10.51% of PS)	915.87
TOTAL	$28,099.36

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 360.23	16
Senior Research Engineers	1,530.02	85
Research Engineers	4,679.90	340
Assistant Research Engineers	116.81	11
Student Assistants	3,305.55	610
Technicians, Machinists	1,976.16	220
Clerical	51.19	8
TOTAL	$12,019.86	1290

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$142,366	$143,852.98	$ - 1,486.98
Materials and Supplies	274,010	284,052.37	-10,042.37
Travel	2,698	1,789.46	908.54
Computer	-0-	-0-	-0-
Overhead	108,198	109,252.68	- 1,054.68
Retirement	13,995	11,672.26	2,322.74
AS PROPOSED	$541,267	$550,619.75	$- 9,352.75

Additional funds have been requested to complete this task. Approximately 90% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 21

1 February through 29 February 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for
U. S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

March 18, 1980

WORK PERFORMED DURING THIS PERIOD

The noise figure test facility (Unit 3), and the phase lock synchronizer (Unit 8) were delivered to MICOM on February 20. These systems were set up and demonstrated for MICOM personnel on that date. Using an HP-8640B oscillator, the frequency agility of the phase lock was demonstrated by sweeping the klystron while it remained locked to the standard source. This capability of the P. S. Henry synchronizer might provide a means for rapidly changing output frequencies of millimeter wave systems while maintianing a narrow-band phase lock.

The 140 GHz system (Unit 2) has been successfully tested on the bench. This transmitter/receiver needs only to be mounted in its chassis and tested again before it will be ready for shipment. It is expected that the tracker mount, corner cubes, and antennas will be delivered in mid-April or earlier if no unforeseen problems occur.

Corner cube calibration loads have been fabricated. A variety of flat aluminum plates with cross sections up to 200 m^2 at both 94 and 140 GHz have been made. As a further check, 1 m^2 cylindrical targets at both frequencies have also been made. It has not yet been possible to make actual measurements of the corner cubes because of bad weather, but these measurements are expected to be completed by 1 April.

The status panel for the tracker mount is complete and its cable is being made. The extra cable and the replacement readout have been received from Contraves.

The spectrum of the 140 GHz EIO has been measured. Figure 1 shows the spectrum measured with an extremely flat drive pulse, such as that pictured in the last monthly progress report. The modulator was then adjusted for the optimum spectrum shown in Figure 2, with the result that the pulse shape was degraded somewhat as shown in Figure 3. Fourier analysis of the rectangular RF output pulse shows that this pulse should have a sin X/X shape, with the sidelobes spaced approximately 20 MHz apart and the largest sidelobes only 7 dB below the main lobe. Figure 1 shows that the sidelobes are about 20 MHz apart,

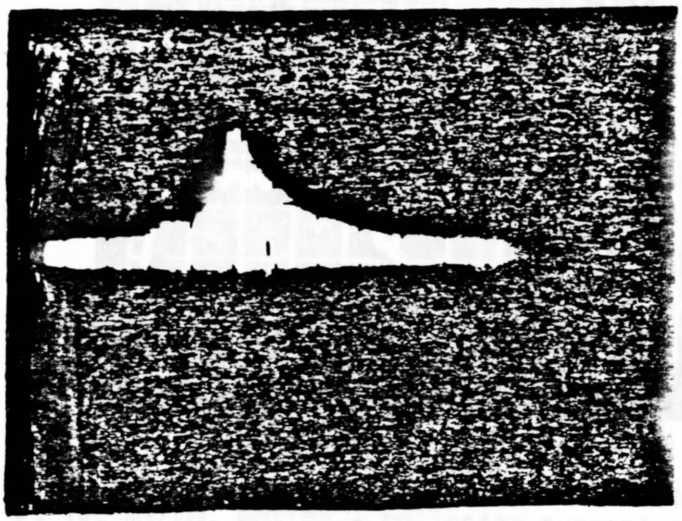


Figure 1. 140 GHz EIO with flat drive pulse, 50 MHz/Div, 10dB/div.

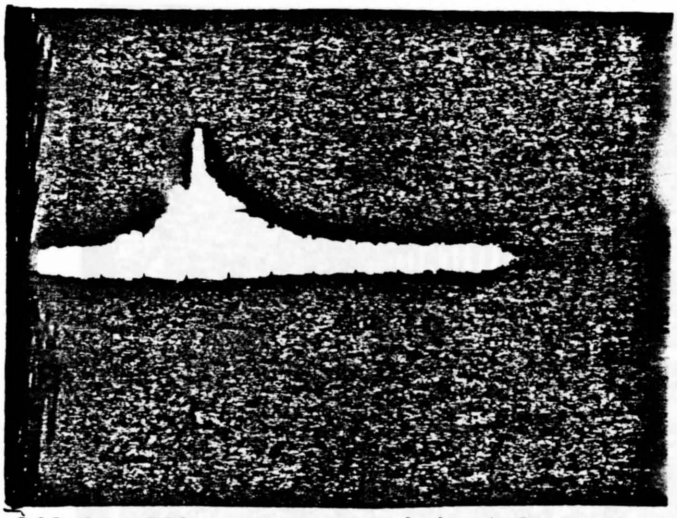


Figure 2. 140 GHz EIO spectrum optimized for narrowest frequency range, 50 MHz/div, 10dB/div.

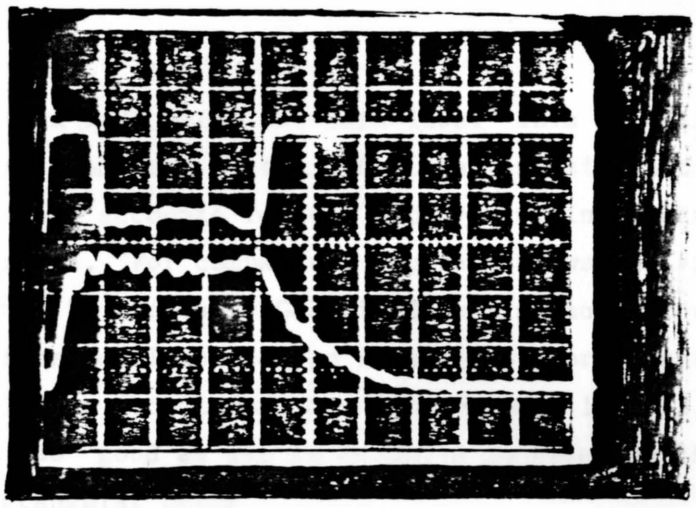


Figure 3. Waveforms corresponding to optimized pulse: top - RF output at 100 mV/cm, bottom - collector current at 100 ma/cm, time 50 ns/cm.

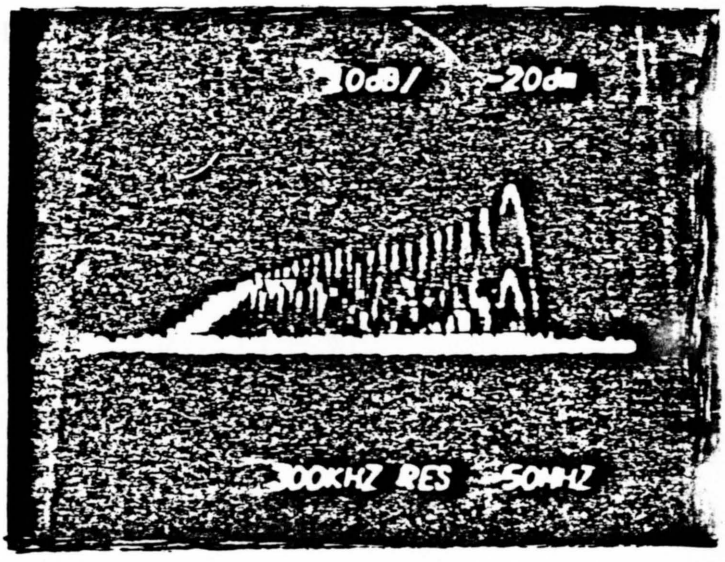


Figure 4. Spectrum of 94 GHz EIO using early Georgia Tech line modulator, 50 MHz/div, 10 dB/div.

but they are less than 7 dB below the main lobe. This is attributed to the frequency chirp exhibited by the EIO during transition times; this chirp also qualitatively accounts for the improvement in spectrum as the pulse shape is degraded. For comparison figure 4 shows the spectrum of a 94 GHz EIO driven by the early Georgia Tech line modulator, showing that the new hard tube modulator design is a great improvement over the earlier design. It is concluded, based on Figures 1 and 3, that the spectrum is about as good as can be expected considering the Fourier transform of the rectangular pulse.

PROBLEMS ENCOUNTERED

There is a continuing shortage of funds on this program, as has previously been noted.

PLANS FOR NEXT PERIOD

The 140 GHz system, tracker mount, corner cubes, and antennas will be essentially completed during the next reporting period.

Cost Information

The following charges have been incurred against the contract during the period 1 February to 29 February 1980.

Personal Services (PS)	$ 4,990.41
Materials and Supplies	5,457.52
Travel	0.00
Overhead (@ 76% of PS)	3,792.71
Retirement (@10.51% of PS)	524.49
TOTAL	$14,765.13

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 180.11	9
Senior Research Engineers	303.16	18
Research Engineers	41.55	3
Assistant Research Engineers	0.00	0
Student Assistants	2,760.64	520
Technicians, Machinists	1,648.83	214
Clerical	56.12	10
TOTAL	$4,990.41	774

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$142,366.00	$148,843.39	$- 6,477.39
Materials and Supplies	274,010.00	289,509.89	-15,499.89
Travel	2,698.00	1,789.46	908.54
Computer	0.00	0.00	0.00
Overhead	108,198.00	113,045.39	- 4,847.39
Retirement	13,995.00	12,196.75	1,798.25
AS PROPOSED	$541,267.00	$565,384.88	$-24,117.88

Additional funds have been requested to complete this task. Approximately 92% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 22

1 March 1980 through 31 March 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R.W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for
U. S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

April 15, 1980

SUMMARY OF WORK

The 140 GHz system is being assembled in its chassis after testing on the bench as reported last month. Most of the effort is being expended in making cables and in wiring the modulator chassis. Projected delivery date for this system is still 19 April. The 140 GHz receiver noise figure has been measured and found to be 8.8 dB.

Some preliminary results have been obtained on the corner cube reflectors at 94 GHz. It is expected that these devices will be delivered along with the 140 GHz system on 19 April. The near field measurement approach using the large antenna did not work because of interference effects, so that it was necessary to separate the transmitter and receiver by about half the far field distance to get good results.

The 140 GHz feed horn for the conscan antenna has been received, and the new subreflector for this antenna has been machined. Present planning also calls for delivery of the antenna on 19 April.

PROBLEMS ENCOUNTERED

No problems not previously reported have been encountered.

PLANS FOR NEXT PERIOD

The systems and components mentioned above will be delivered during the next period.

Cost Information

The following charges have been incurred against the contract during the period 1 March 1980 through 31 March 1980.

Personal Services (PS)	$ 3,805.68
Materials and Supplies	2,368.66
Travel	0.00
Overhead (@ 76% of PS)	2,892.32
Retirement (@10.51% of PS)	399.98
TOTAL	$ 9,466.64

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 0.00	0
Senior Research Engineers	0.00	0
Research Engineers	231.83	17
Assistant Research Engineers	561.75	52
Student Assistants	1,762.66	332
Technicians, Machinists	1,249.44	144
Clerical	0.00	0
TOTAL	$ 3,805.68	545

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$ 142,366	$ 152,649.07	$ -10,283.07
Materials and Supplies	274,010	291,878.55	-17,868.55
Travel	2,698	2,238.33	459.67
Computer	0	0.00	0.00
Overhead	108,198	115,937.71	- 7,739.71
Retirement	13,995	12,121.33	1,873.67
AS PROPOSED	$ 541,267	$ 574,824.99	-33,557.99

Additional funds have been requested to complete this task. Approximately 93% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 23

1 April 1980 through 30 April 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R.W. McMillan

Contract DAAK40-78-C-0158
(A-2166)

Prepared for
U. S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

May 20, 1980

SUMMARY OF WORK

Units 2,5,6, and 7 were delivered on 6 and 7 May, 1980, and some abbreviated measurements of the performance of Unit 2 (140 GHz Transmitter/Receiver) were made at that time. Among the targets seen with this system were corner cubes at various ranges, cars at about 400 m, rain backscatter, and a hillside at a range of about 1800 m. Based on these qualitative results, it was concluded that the 140 GHz system is performing at its expected level. Similar qualitative performance measurements on units 5,6, and 7 indicate that these systems are also meeting their specifications.

Work has begun on bench assembly of the frequency translator, although the phase-locked 4 GHz oscillator for this unit has not yet been received. This oscillator was scheduled for delivery in early May.

The 94 GHz modulator has been tested, but the risetime of this device is about 30 ns which is slower than that of those devices already tested. This slower rise time is attributed to the greater voltage swing ($\sim$18 kV) required for the 94 GHz EIO as compared to the higher frequency tubes. This problem is being investigated by the EES modulator group at the Cobb County Facility.

PROBLEMS ENCOUNTERED

Slow modulator rise time, as noted above, is the only previously unreported problem.

PLANS FOR NEXT PERIOD

Work will continue on the frequency translator. The 94 GHz modulator will be delivered and locking experiments on the EIO will begin.

Cost Information

The following charges have been incurred against the contract during the period 1 April to 30 April 1980.

Personal Services (PS)	9124.70
Materials and Supplies	344.54
Travel	0.00
Overhead (@ 76% of PS)	6934.77
Retirement (@10.51% of PS)	845.96
TOTAL	17,249.97

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	0.00	0
Senior Research Engineers	1617.84	95
Research Engineers	3301.92	247
Assistant Research Engineers	112.35	10
Student Assistants	1075.53	203
Technicians, Machinists	2829.85	376
Clerical	187.21	32
TOTAL	9124.70	913

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	142,366	161,773.77	-19,407.77
Materials and Supplies	274,010	292,223.09	-18,213.09
Travel	2698	2238.33	459.67
Computer	0	0.00	0.00
Overhead	108,198	122,872.48	-14,674.48
Retirement	13,995	12,967.29	1,027.71
AS PROPOSED	541,267	592,074.96	-50,807.96

An additional $63K not included in the above figures, will be available to complete this task. Approximately 95% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 24

1 May 1980 through 31 May 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R.W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command

Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

June 17, 1980

SUMMARY OF WORK

The 94 GHz modulator has been delivered by the EES Radar Laboratory. The EIO was operated with this modulator and the EIO current and RF output waveforms are shown in Figure 1. The spectrum of this tube is shown in Figure 2 which is the 750 MHz beat between the EIO and the 93.25 GHz Gunn oscillator. Using this modulator, the designers were able to demonstrate a high voltage pulse flatness of $\pm$ 30 volts on the EIO cathode pulse. Unfortunately, it was necessary to make some minor changes in modulator adjustments to bring the tube to the proper frequency so that this degree of flatness was lost, but it will not be difficult to readjust the modulator to achieve it again. The spectrum of Figure 2 is a further indication that the cathode drive pulse is not extremely flat.

A preliminary attempt was made to injection lock the EIO using the 94 GHz klystron, but no change was noted in the spectrum upon injecting klystron power. Part of the problem is attributed to the fact that the klystron was not phase locked, because the locking circuitry had failed. Further attempts will be made to injection lock the EIO when the phase lock is repaired.

PROBLEMS ENCOUNTERED

The injection locking problem mentioned earlier is the only problem encountered during this period.

PLANS FOR NEXT PERIOD

The phase lock circuitry for the 94 GHz EIO will be available during the next reporting period, and simultaneous phase and injection locking of the EIO will be attempted.

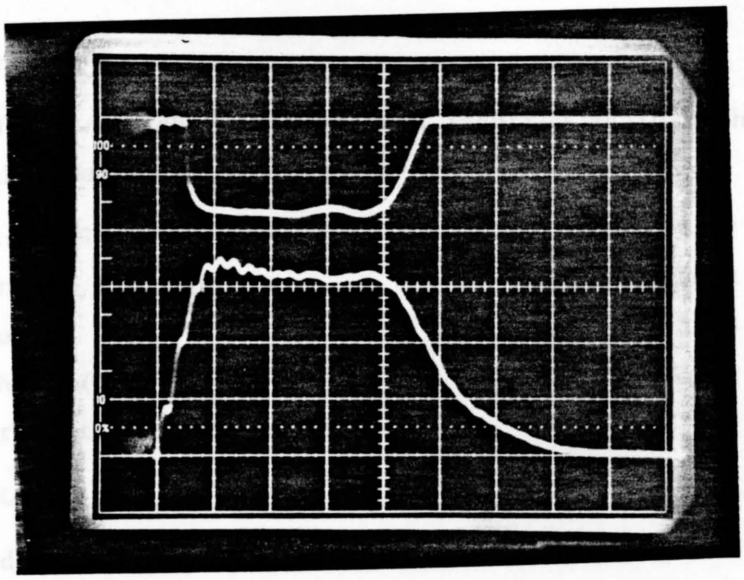


Figure 1. RF output, 20 mV/cm, and EIO current, 200 ma/cm, for 94 GHz EIO. The sweep speed is 50 ns/cm.

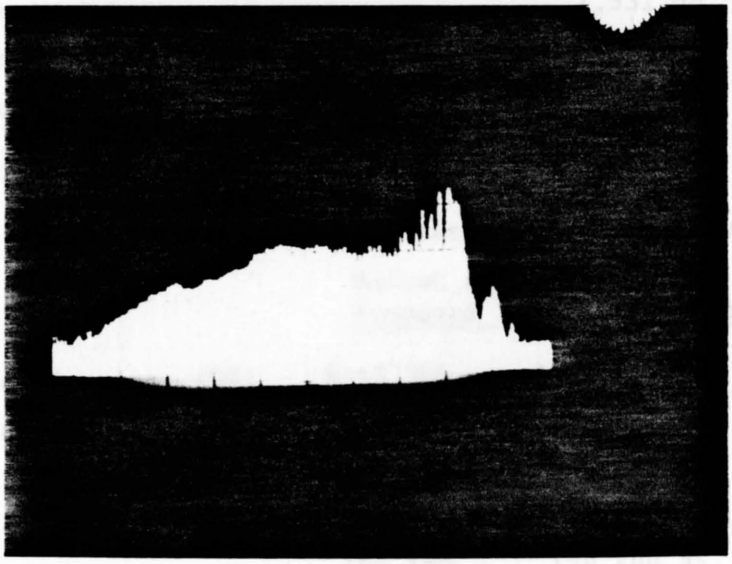


Figure 2. 94 GHz EIO spectrum, 50 MHz/div, 10 db/div.

Cost Information

The following charges have been incurred against the contract during the period 1 May to 31 May 1980.

Personal Services (PS)	$ 7,403.77
Materials and Supplies	224.18
Travel	378.73
Overhead (@ 76% of PS)	5,626.87
Retirement (@10.51% of PS)	617.22
TOTAL	$14,250.77

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 360.23	17
Senior Research Engineers	1,685.25	99
Research Engineers	2,011.60	150
Assistant Research Engineers	1,224.70	113
Student Assistants	1,531.08	288
Technicians, Machinists	546.00	71
Clerical	44.91	8
TOTAL	$ 7,403.77	746

The current financial status of the contract is as follows:

	Budget As Proposed	Expended	Free Balance
Personal Services (PS)	$142,366	$169,177.54	$-26,811.54
Materials and Supplies	274,010	292,447.27	-18,437.27
Travel	2,698	2,617.06	80.94
Computer	0	0.00	0.00
Overhead	108,198	128,499.35	-20,301.35
Retirement	13,995	13,584.51	410.49
AS PROPOSED	$541,267	$606,325.73	$-65,058.73

Additional funding has been requested to complete this task. The above figures do not include an additional $63K of funding already approved. Approximately 96% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 25

1 June 1980 through 30 June 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R.W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

July 24, 1980

SUMMARY OF WORK

The 94 GHz transmitter subsystem was assembled on the bench and initial attempts to injection lock the EIO were made, while monitoring the EIO spectrum. The spectrum was monitored by mixing the EIO output with the output of the phase locked Gunn oscillator. A spectrum measured in this way was shown in the last monthly progress report.

No improvement in the EIO spectrum was observed during the experiment described above, and it was decided that the power output of the injection locking klystron is probably not high enough to affect the EIO spectrum when the latter tube is operated at high power. The EIO power output was then reduced, but the modulation coupling capacitor failed before the effects of this power reduction could be evaluated. The modulator has been repaired, and this locking experiment will be continued during the next reporting period.

The phase lock system delivered earlier to MICOM has been returned to Georgia Tech for repair. At present, the problem with this system has not been found, but little difficulty in repairing it is anticipated.

PROBLEMS ENCOUNTERED

There is a continuing problem with poor mechanical stability of the Hughes mixers, which is not too severe for those applications in which the mixer is hard mounted in a system, but has resulted in numerous failures in mixers used on the bench. For example, a total of six mechanical failures has occurred in the phase lock mixer, as a result of connecting and disconnecting this device. This problem could probably be solved by buying these mixers from Custom Microwave, and this possibility will be examined.

PLANS FOR NEXT PERIOD

The phase and injection locking experiments on the 94 GHz EIO will continue. The phase lock system will be repaired, and the possibility of purchasing mixers from Custom Microwave will be examined.

Cost Information

The following charges have been incurred against the contract during the period 1 June to 30 June 1980.

Personal Services (PS)	$1,155.92
Materials and Supplies	23.96
Travel	0
Overhead (@ 76% of PS)	878.50
Retirement (@11.11% of PS)	80.26
TOTAL	$2,138.64

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	--	
Senior Research Engineers	--	
Research Engineers	$374.50	28
Assistant Research Engineers	176.55	16
Student Assistants	392.35	74
Technicians, Machinists	191.52	25
Clerical	21.00	4
TOTAL	$1,155.92	147

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$179,173.98	$170,333.46	$ 8,840.52
Materials and Supplies	248,151.34	292,471.23	(44,319.89)
Travel	2,698.00	2,617.06	80.94
Computer	400.00	0.00	400.00
Overhead	136,172.50	129,377.85	6,794.65
Retirement	17,770.18	13,664.77	4,105.41
AS PROPOSED	$584,366.00	$608,464.37	$(24,098.37)

Additional funding has been requested to complete this task. The above figures do not include an additional $20K of funding already approved. Approximately 96% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 26

1 July 1980 through 31 July 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R.W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

August 14, 1980

SUMMARY OF WORK

Some progress has been made in injection locking the 94 GHz EIO. Before any effect of the injection locking signal on the EIO spectrum could be observed, it was necessary to carefully readjust the modulator pulse segments to obtain the flattest possible pulse, which should correspond to the best frequency spectrum. Figure 1a shows the EIO spectrum resulting from these adjustments. The output of the 94 GHz phase locked klystron was then fed into the EIO, with the result shown in Figure 1b. Note that the sidelobe levels are reduced by about 2 dB, and that the general appearance of the spectrum is improved, showing that the injection signal has some positive effect on the EIO spectrum.

Some other effects of the injection locking signal were noted: (1) the EIO output pulse begins earlier after the cathode current pulse is applied, and (2) the start-up jitter of the RF pulse is almost totally eliminated by injection locking. This latter effect seemed to depend little on either the frequency or the power level of the injection signal.

The EIO phase locking system has also been tried, both with and without injection locking. This circuit had almost no effect on the spectrum, and it is currently being tested to be sure that it is working properly. The phase lock will be tried again when these tests are completed.

Little time remains for experimentation if the 94 GHz system is to be packaged and shipped before October 1. For this reason, it will be necessary to stop the experiments and finish the packaging at the beginning of the third week in August.

PROBLEMS ENCOUNTERED DURING THIS PERIOD

The Hughes 93.25 GHz phase locked Gunn oscillator is giving some problems again. This device requires about one hour or more to begin oscillating after power is applied. This may be a sign that the characteristics of the Gunn device are degrading.

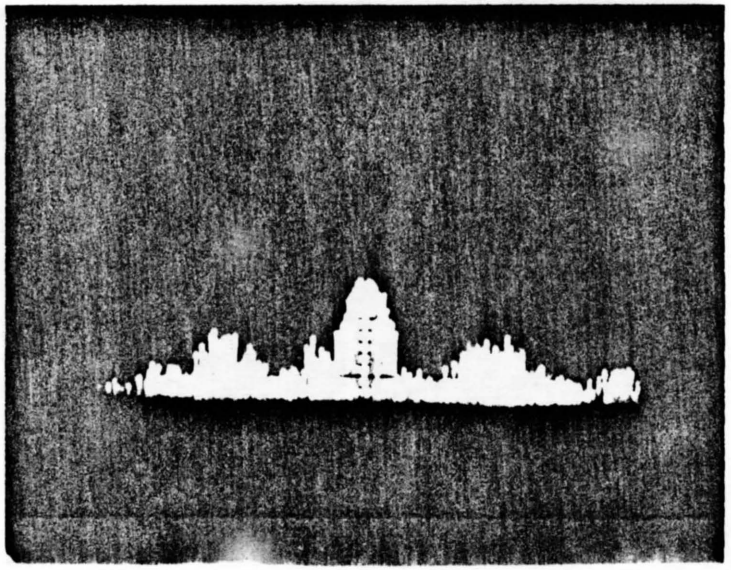


Figure 1a. Spectrum of 94 GHz EIO without injection locking, 10 MHz/div, 10 dB/div.

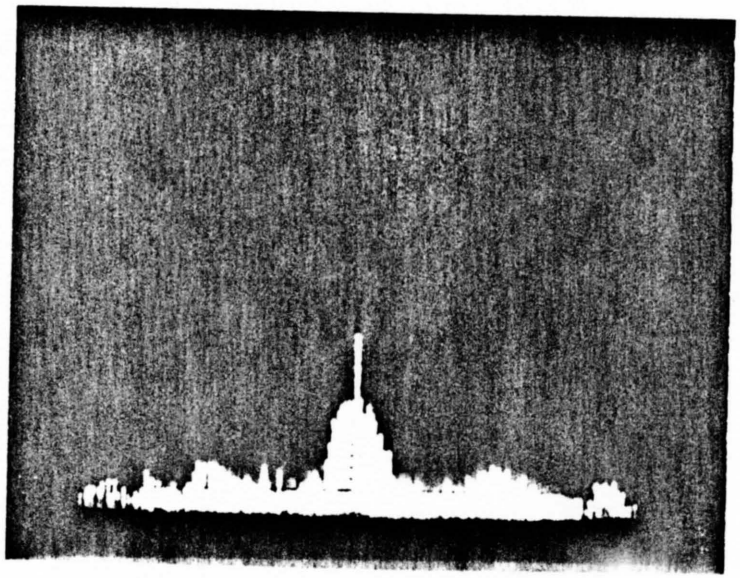


Figure 1b. Spectrum of 94 GHz EIO with injection locking, 10 MHz/div, 10 dB/div.

The 3.6 GHz phase locked oscillator ordered from Miteq for the frequency translator is about 2 months overdue. This oscillator is now scheduled to be shipped about 1 September.

PLANS FOR NEXT PERIOD

Most of the packaging of the 94 GHz transmitter/receiver and the frequency translator is expected to be completed during the next reporting period.

Cost Information

The following charges have been incurred against the contract during the period 1 July 1980 to 31 July 1980 .

Personal Services (PS)	$2,014.92
Materials and Supplies	742.18
Travel	275.00
Overhead (@ 76% of PS)	1,470.89
Retirement (@11.11% of PS)	182.65
TOTAL	$4,685.64

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers		
Senior Research Engineers		
Research Engineers	$1194.82	89
Assistant Research Engineers	146.23	13
Student Assistants	370.93	70
Technicians, Machinists	154.00	20
Clerical	148.94	28
TOTAL	$2014.92	220

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$179,173.98	$172,348.38	$ 6,825.60
Materials and Supplies	248,151.34	292,494.25	(44,342.91)
Travel	2,698.00	2,892.06	(194.06)
Computer	400.00	0.00	400.00
Overhead	136,172.50	130,848.74	5,323.76
Retirement	17,770.18	13,847.42	3,922.76
AS PROPOSED	$584,366.00	$612,430.85	(28, 064.85)

Additional funding has been requested to complete this task. Approximately 97% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 27

1 August 1980 through 31 August 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35809

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

September 18, 1980

SUMMARY OF WORK

The 94 GHz system is being assembled on its chassis. Layout of the components is being done and the required waveguide runs are being made. Cables have already been fabricated. The chassis for the 94 GHz system has been designed to be interchangeable in the Contraves gimbal with that of the 140 GHz system already delivered; the chasses will be identical except that the 94 GHz system chassis will be longer. It is expected that the 94 GHz system will be tested in the chassis early in the week of September 22.

PROBLEM ENCOUNTERED

Miteq advises us that they will not be able to ship the 3.7 - 4.2 GHz phase locked oscillator for the frequency translator until September 30. It will therefore not be possible to deliver the translator until after this date.

PLANS FOR NEXT PERIOD

Both the 94 GHz system and the frequency translator system are expected to be delivered during the next reporting period.

Cost Information

The following charges have been incurred against the contract during the period 1 August to 31 August 1980.

Personal Services (PS)	4555.51
Materials and Supplies	197.68
Travel	-200.00
Overhead (@ 76% of PS)	3325.52
Retirement (@11.11% of PS)	457.25
TOTAL	8335.96

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers		
Senior Research Engineers	657.87	39
Research Engineers	2500.67	187
Assistant Research Engineers		
Student Assistants	439.90	83
Technicians, Machinists	908.66	105
Clerical	48.41	8
TOTAL	4555.51	422

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	200,422.98	178,903.89	23,519.09
Materials and Supplies	248,151.34	292,691.93	-44,540.59
Travel	2,698.00	2,692.06	5.94
Computer	400.00	0.00	400.00
Overhead	152,321.74	134,174.26	18,147.48
Retirement	20,130.94	14,304.67	5,826.27
AS PROPOSED	624,125.00	620,766.81	3,358.19

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 98% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 28

1 September 1980 to 30 September 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U. S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

October 23, 1980

SUMMARY OF WORK

The 94 GHz coherent system is in the final stages of assembly. The EIO has been tested in the chassis with the 50 foot cables and has been found to work satisfactorily. Unfortunately, the Hughes Gunn oscillator has failed again, which will delay delivery of this system by several weeks, depending on the turn-around time that Hughes can give us on repair of this device. This failure occurred during measurement of the receiver noise figure. Mr. Steve Gekko of Hughes Solid State Marketing advises us that he has received the Gunn but cannot give us an estimate on repair time until his engineers have an opportunity to analyze the problem.

The 3.7-4.2 GHz phase locked source for the frequency translator has not yet been received from Miteq. This device was to have been shipped on 30 September. Components for the translator are being mounted on the chassis, and this unit will be ready for initial testing when the source is received.

PROBLEMS ENCOUNTERED

The failure of the phase locked Gunn will delay delivery of the 94 GHz system as noted above.

PLANS FOR NEXT PERIOD

The 94 GHz system will be delivered if the Gunn oscillator can be repaired and returned on time.

Cost Information

The following charges have been incurred against the contract during the period 1 September 1980 to 30 September 1980.

Personal Services (PS)	$4,395.31
Materials and Supplies	1,173.63
Travel	0.00
Overhead (@ 76% of PS)	3,208.58
Retirement (@11.11% of PS)	432.02
TOTAL	$9,200.54

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers		
Senior Research Engineers	$ 167.63	10
Research Engineers	2,011.60	150
Assistant Research Engineers	196.16	18
Student Assistants	461.70	87
Technicians, Machinists	1,356.15	157
Clerical	202.07	33
TOTAL	$4,395.31	455

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	201,291.98	181,299.20	19,992.78
Materials and Supplies	248,151.34	293,865.56	(45,714.22)
Travel	2,698.00	2,692.06	5.94
Computer	400.00	0.00	400.00
Overhead	152,493.50	137,382.84	15,110.66
Retirement	19,090.18	14,727.69	4,362.49
AS PROPOSED	$624,125.00	$629,967.35	($5,842.35)

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 98% of the proposed task has been completed; however, additional time and funds have been requested to implement an option to the phase-locked Gunn oscillator which has failed and to provide adequate time to adjust the parameters of the phase and injection locked circuits for maximum EIO stability.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 29

1 October 1980 to 31 October 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U. S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

November 18, 1980

SUMMARY OF WORK

The Hughes phase locked Gunn oscillator has failed for the fourth time, and has been returned to Hughes. This failure is different from that reported in the last monthly progress report, and apparently involves the 7.8 GHz reference source made by California Microwave, since the Gunn device itself still oscillates with good power. Hughes has promised us quick turn-around of this source, and demonstrated their willingness to cooperate with us after the last Gunn failure, which they repaired and returned in less than two weeks.

An additional problem with the coupling cavity on the 94 GHz receiver has occurred. Apparently this device was distorted while being clamped into place, and must be machined again. The cavity is expected to be available before the Gunn oscillator is received from Hughes.

The 3.7 - 4.2 GHz source for the frequency translator has been shipped by Miteq, who were ready to ship about two weeks ago but experienced a failure in the power output stage during burn-in.

PROBLEMS ENCOUNTERED

The failure of the Gunn oscillator and the difficulty with the coupling cavity were the only problems encountered.

PLANS FOR NEXT PERIOD

Phase and injection locking experiments with the 94 GHz system will continue upon receipt of the Gunn source. Initial testing of the frequency translator will begin.

Cost Information

The following charges have been incurred against the contract during the period 1 October to 31 October 1980.

Personal Services (PS)	2,905.15
Materials and Supplies	857.81
Travel	0.00
Overhead (@ 73% of PS)	2,120.76
Retirement (@11.11% of PS)	213.03
TOTAL	6,096.75

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers		
Senior Research Engineers	167.63	8
Research Engineers	838.16	55
Assistant Research Engineers	0.00	0
Student Assistants	791.75	142
Technicians, Machinists	1,086.86	114
Clerical	20.75	3
TOTAL	2,905.15	322

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$201,291.98	$184,204,35	$17,087.63
Materials and Supplies	248,151.34	294,723.37	(46,572.03)
Travel	2,698.00	2,692.06	5.94
Computer	400.00	0.00	400.00
Overhead	152,493.50	139,503.60	12,989.90
Retirement	19,090.18	14,940.72	4,149.46
AS PROPOSED	$624,125.00	$636,064.10	($11,939.10)

Additional funds have been requested from MICOM to complete this task. Approximately 98% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 30

1 November 1980 to 30 November 1980

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

December 30, 1980

Summary Of Work

A very low level of effort is currently being expended on this program because of the lack of funds. However, several important problems are being addressed as time from other programs permits.

The Hughes mixers are being contacted using new bellows springs that were obtained from Servometer Corporation for the IF contact, so that they should be much more reliable. One of these mixers remains to be modified.

The Gunn oscillator has been repaired and returned by Hughes. Apparently the 7.8 GHz California Microwave reference source had failed this time.

A significant improvement in performance and complexity has been made on the modulator being built for the Army Night Vision Laboratory 225 GHz radar. This circuit incorporates a "tail-biter" which gives good trailing edge time response for the EIO pulse, while allowing for a larger value of plate load resistance in the modulator tube. The output pulse flatness of this modulator has been determined to be less than 40 V for an 8 KV modulator pulse. The circuit is also improved because the incrementally adjustable pulse flatness controls are eliminated, and the EIO will operate at a higher PRF for a given power supply.

Figure 1 shows the spectrum of the 225 GHz EIO when driven by this modulator. The asymmetry is apparently caused by the 40 V of residual chirp on the pulse, but the deep nulls between lobes indicate that there is little FM noise aside from this chirp. Despite this problem, it appears that this modulator would lend itself to phase locking more readily than the earlier design.

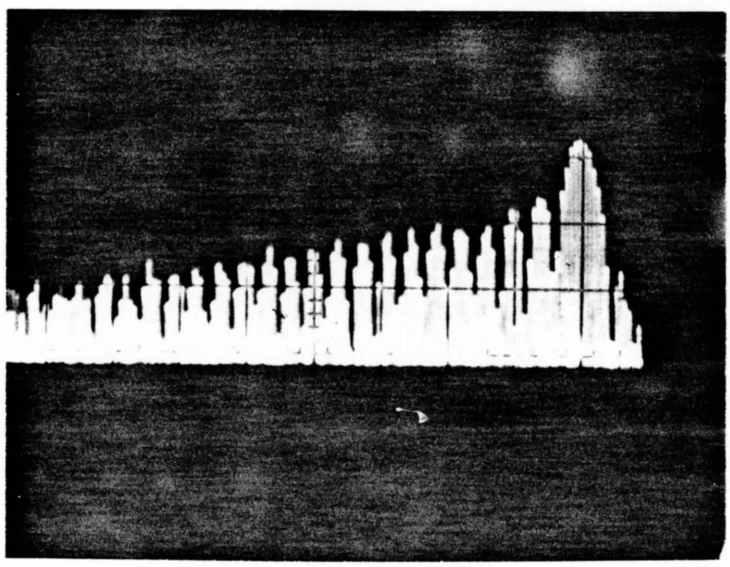


Figure 1. Spectrum of the 225 GHz EIO for a 300 ns Pulse Width. The Horizontal Scale is 10 MHz/div and the Vertical Scale is 10 dB/div.

Problems Encountered

No previously unreported problems have been encountered.

Plans For Next Period

Work will continue on the program at a low level of effort as time permits.

Cost Information

The following charges have been incurred against the contract during the period 1 November 1980 to 30 November 1980.

Personal Services (PS)	1420.01
Materials and Supplies	310.91
Travel	0.00
Overhead (@ 76% of PS)	1036.61
Retirement (@11.11% of PS)	147.65
TOTAL	2915.18

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	0.00	
Senior Research Engineers	0.00	
Research Engineers	733.39	48
Assistant Research Engineers	125.27	10
Student Assistants	91.00	16
Technicians, Machinists	153.99 254.12	19 27
Clerical	62.24	9
TOTAL		

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	201,291.98	185,624.35	15,667.62
Materials and Supplies	248,151.34	295,034.28	(46,882.94)
Travel	2,698.00	2,692.06	5.94
Computer	400.00	0.00	400.00
Overhead	152,493.50	140,540.21	11,953.29
Retirement	19,090.18	15,088.37	4,001.81
AS PROPOSED	624,125.00	638,979.28	(14,854.28)

Additional funds have been requested to complete this task. Approximately 98% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 31

1 December 1980 to 31 December 1981

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

January 15, 1981

Summary of Work

The 93.25 GHz Gunn oscillator, recently returned by Hughes, has been remounted in the receiver and tested. The receiver noise figure tests can therefore be continued when the coupling cavity has been properly adjusted. Since all of the Hughes mixers have now been recontacted with the new bellows IF contacts, it will be possible to choose the best possible mixer for this receiver.

A different output stage for the EIO phase lock is being designed, both for the 94 GHz system and for the 225 GHz radar. This modification will have a lower output impedance than that tried earlier, and will thus have better control of the EIO body voltage.

The frequency translator is being assembled and will be ready for integrated system tests during the next reporting period. The 94 GHz klystron returned to Varian for repair, which belongs to this system, has not yet been received. Varian has agreed to repair this tube free of charge.

A connector for the klystron reflector has been mounted on the rear of the phase lock chassis, previously returned to EES for repair. When this unit was initially delivered to MICOM, the proper connector was not available.

Problems Encountered

There is some difficulty with adjustment of the receiver coupling cavity, as noted above. This problem is expected to be solved in the next reporting period.

Plans for Next Period

The 94 GHz receiver noise figure will be measured and the modified phase lock output stage will be tried. Preliminary tests of the frequency translator will be made.

Cost Information

The following charges have been incurred against the contract during the period 1 December 1980 to 31 December 1980

Personal Services (PS)	$102.00
Materials and Supplies	44.80
Travel	0.00
Overhead (@ 73% of PS)	74.46
Retirement (@11.11% of PS)	4.62
TOTAL	$225.88

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	-	-
Senior Research Engineers	-	-
Research Engineers	-	-
Assistant Research Engineers	-	-
Student Assistants	60.50	7
Technicians, Machinists	-	-
Clerical	41.50	6
TOTAL	$102.00	13

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$216,943.98	$185,726.36	$31,217.62
Materials and Supplies	248,151.34	295,079.08	(46,927.74)
Travel	2,698.00	2,692.06	5.94
Computer	400.00	.00	400.00
Overhead	163,919.50	140,614.67	23,304.83
Retirement	20,829.18	15,092.99	5,736.19
AS PROPOSED	$652,942.00	$639,205.16	$13,736.84

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 98% of the proposed task has been completed. Additional funds have been received from MICOM to complete the task and are noted in the above financial report.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 32

1 January 1981 to 31 January 1981

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

February 18, 1981

Summary of Work

The frequency translator is essentially complete, and tests of this system are beginning. It will be recalled that the phase lock built for the translator is the first Henry circuit to be built at Georgia Tech, so that final testing and adjustments should be minimal. The frequency translator, together with the phase lock returned to Georgia Tech for repair, will be delivered during the next reporting period.

The phase lock system (Unit 8) is operational, and requires only some minor adjustments before being delivered about 1 March. Some problems are still being encountered with the phase lock mixers used in both Unit 8 and the frequency translator. Replacement of the bellows springs in these mixers solved the original mechanical problem, but the whisker now seems to be breaking contact with the chip. If this problem persists, alternative contacting approaches will be tried.

The illness of the division machinist, who was working on the 94 GHz coupling cavities, has resulted in these devices being reassigned to the main Georgia Tech machine shop. It is expected that the cavities will finally be ready during the next reporting period.

The output stage for the EIO phase lock driver has been designed, but difficulty in finding a suitable transistor has been encountered. It may be necessary to compromise the output voltage swing of the stage in order to permit use of transistors with sufficient bandwidth for this application.

Problems Encountered

The problems with phase lock mixers, coupling cavities, and choice of phase lock output stage transistor, as noted above, are the only

difficulties encountered.

Plans for Next Period

The frequency translator and the phase lock will be delivered. Work will continue on phase locking of the 94 GHz EIO.

Cost Information

The following charges have been incurred against the contract during the period 1 January 1981 to 31 January 1981 .

Personal Services (PS)	$2,208.29
Materials and Supplies	480.72
Travel	0.00
Overhead (@ 76% of PS)	1,612.05
Retirement (@11.11% of PS)	245.36
TOTAL	$4,546.42

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	0.00	0
Senior Research Engineers	0.00	0
Research Engineers	859.12	56
Assistant Research Engineers	784.66	145
Student Assistants	0.00	0
Technicians, Machinists	423.54	44
Clerical	140.97	22
TOTAL	$2,208.29	267

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$216,943.98	$187,934.65	$29,009.33
Materials and Supplies	248,151.34	295,559.80	(47,408.46)
Travel	2,698.00	2,692.06	5.94
Computer	400.00	0.00	400.00
Overhead	163,919.50	142,226.72	21,692.78
Retirement	20,829.18	15,338.35	5,490.83
AS PROPOSED	$652,942.00	643,751.58	9,190.42

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 99% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 33

1 February 1981 to 28 February 1981

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R.W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

March 18, 1981

Summary of Work

The receiver coupling cavity for the 94 GHz system has been machined again and is being tested. The other two cavities for this system are being modified, but these changes are expected to be minimal because of the non-critical nature of these devices. It will be possible to measure the noise figure of the 94 GHz receiver when testing of the receiver cavity is complete.

An output stage which will probably be suitable for driving the EIO body for phase locking has been designed and tested, although transistors are not yet available to provide the desired $\pm$ 80V output swing. The stage which will be used for testing will have a swing of about $\pm$ 25V due to limitations on the breakdown of the available transistors, but higher voltage devices have been ordered and delivery is expected from stock. This output stage uses enhancement mode field effect transistors and has a 3 dB bandwidth of about 7 MHz and a rise time of less than 50 ns. Recent circuit improvements have reduced the rise time to about 20 ns, although the bandwidth has not been measured for this case.

The frequency translator is ready for delivery. Some last minute problems were encountered with this system because some of the high frequency dc amplifiers used in the phase lock were found to be oscillating. These oscillations contributed to general instability of the phase lock in addition to causing spurious responses in the phase lock operation. These problems were corrected by changing the circuit layout to minimize lead lengths at the summing junctions of the high frequency amplifiers. The translator phase lock has been successfully used to lock both 94 and 140 GHz klystrons.

The phase lock system previously delivered to MICOM and returned to Georgia Tech for repair and readjustment is also working properly. It is expected that both the translator and the phase lock will be delivered during the week of 16 March.

The long-standing problem with the signal processor to be used with the 94 and 140 GHz systems has been found, and this subsystem is now working properly. Following a bit of clean-up, this unit can also be delivered. Some input from MICOM on the software capability to be furnished will probably be required, and the processor will need to be delivered and set up by Georgia Tech personnel.

Problems Encountered

No previously unreported problems have been encountered during this reporting period.

Plans for Next Period

The translator will be delivered, and work will begin anew on the 94 GHz system including receiver noise figure measurements and phase locking experiments.

Cost Information A-2166

The following charges have been incurred against the contract during the period Feb. 1, 1981 - Feb. 28, 1981 .

Personal Services (PS)	$2,421.68
Materials and Supplies	463.06
Travel	0.00
Overhead (@ 76% of PS)	1,767.83
Retirement (@11.11% of PS)	243.80
TOTAL	$4,896.37

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 0.00	0
Senior Research Engineers	386.98	20
Research Engineers	1,278.20	83
Assistant Research Engineers	0.00	0
Student Assistants	227.13	40
Technicians, Machinists	428.85	52
Clerical	99.00	15
TOTAL	$2,321.16	210

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$216,943.98	$190,356.33	$26,587.65
Materials and Supplies	248,151.34	296,022.86	(47,871.52)
Travel	2,698.00	2,692.06	5.94
Computer	400.00	0.00	400.00
Overhead	163,919.50	145,762.38	18,157.12
Retirement	20,829.18	15,582.15	5,247.03
AS PROPOSED	$652,942.00	$650,415.78	$2,526.22

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 99% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 34

1 March 1981 to 31 March 1981

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for

U.S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

April 17, 1981

Summary of Work

The coupling cavities for both phase locking and for the receiver mixer are almost complete. The problem with these devices has been high loss caused by inaccurate machining of the cavities themselves and of the input and output waveguides. The cavities are now being gold-plated prior to final tuning.

Substantial progress has been made in getting the 94 GHz system operational. The injection locking klystron has been locked to the Gunn oscillator and the EIO has also been tested in its final configuration. Unfortunately, the high voltage wire in the phase lock board has broken down to the board ground plane on two occasions, doing considerable damage to the board and the phase lock power supply. The problem has been traced to faulty test lead wire that was used to wire the phase lock board; pinholes in the wire were breaking down to the ground plane. This wire is being replaced.

The phase lock board for the frequency translator is being rebuilt on a ground plane board to eliminate the stability problems encountered earlier.

It is expected that the remaining components of the millimeter guidance technology hardware system will delivered around 1 May, if the remaining small problems can be solved. Fortunately, no insurmountable problems have yet been encountered.

Problems Encountered

The phase lock board arcing problem noted above is the only previously unreported problem.

Plans for Next Period

It is expected that the remaining hardware components of this program will be delivered.

Cost Information

The following charges have been incurred against the contract during the period March 1, 1981 - March 31, 1981.

Personal Services (PS)	2,158.04
Materials and Supplies	126.53
Travel	248.00
Overhead (@73%of PS)	1,575.37
Retirement (@11.11% of PS)	230.27
TOTAL	4,338.21

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers		
Senior Research Engineers	503.08	26.08
Research Engineers		
Assistant Research Engineers	1,147.03	93.30
Student Assistants	85.25	15.30
Technicians, Machinists	338.83	35.40
Clerical	83.85	12.80
TOTAL	2,158.04	182.88

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$ 216,943.98	$ 192,514.37	$ 24,429.61
Materials and Supplies	248,151.34	296,149.39	(47,998.05)
Travel	2,698.00	2,940.06	(242.06)
Computer	400.00	0.00	400.00
Overhead	163,919.50	145,569.92	18,349.58
Retirement	20,829.18	15,812.42	5,016.76
AS PROPOSED	$ 652,942.00	$ 652,986.16	$ (44.16)

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 99% of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 35

1 April 1981 to 30 April 1981

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for
U.S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

May 18, 1981

Summary of Work

The remaining components of this system are almost ready for delivery. All of the 94 GHz subsystems have been tested individually and are working well. Check-out of the 94 GHz hardware will be complete when all systems are tested together.

The spectrum of the 94 GHz EIO is quite good and was obtained simply by careful adjustment of the modulator incremental amplitude controls. The spectrum is expected to improve with the phase and injection locking.

The frequency translator phase lock has been rebuilt on a ground plane board. The board has been tested and no evidence of the oscillation problems seen with the other board were observed. This phase lock must still be tested with the translator tubes, however.

Problems Encountered

Several problems were encountered in integrating the 94 GHz system, but none was insurmountable, and they are not expected to interfere with delivery of the system.

Plans for Next Period

It is expected that the remaining hardware components of this system will be delivered during the third week in May.

Cost Information A-2166

The following charges have been incurred against the contract during the period April 1, 1981 - April 30, 1981 .

Personal Services (PS)	$1,210.39
Materials and Supplies	330.92
Travel	-34.39
Overhead (@ 73% of PS)	883.58
Retirement (@11.11% of PS)	124.44
TOTAL	$2,514.94

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	$ 0.00	0
Senior Research Engineers	0.00	0
Research Engineers	0.00	0
Assistant Research Engineers	980.29	80
Student Assistants	90.30	16
Technicians, Machinists	123.20	15
Clerical	16.60	2.5
TOTAL	$1,210.39	113.5

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$216,943.98	$193,724.76	$23,219.22
Materials and Supplies	248,151.34	296,480.31	(48,328.97)
Travel	2,698.00	2,905.67	(207.67)
Computer	400.00	0.00	400.00
Overhead	163.919.50	146,453.50	17,466.00
Retirement	20,829.18	15.936.86	4.892.32
AS PROPOSED	$652,942.00	$655,501.10	(2,559.10)

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately99.6%of the proposed task has been completed.

MONTHLY LETTER REPORT (TECHNICAL)

AND

COST AND PERFORMANCE

Report No. 36

1 May 1981 to 31 May 1981

MILLIMETER GUIDANCE TECHNOLOGY HARDWARE

Project Director: R. W. McMillan

Contract DAAK40-78-C-0158

(A-2166)

Prepared for
U.S. Army Missile Command
Redstone Arsenal, Alabama 35898

Prepared by
Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

June 15, 1981

Summary of Work

All of the hardware components of this program have been delivered with the exception of the data processing hardware to be used with the 94 and 140 GHz systems. The software bugs that have plagued this subsystem have been worked out, but now there is a problem with the disk reader. It is expected that this problem will be solved during June, and the signal processor can then be delivered.

The frequency translator, which has worked well at Georgia Tech before two previous deliveries, has again failed to perform at MICOM, and has been brought back to Georgia Tech for readjustment. This unit will be delivered again in early July.

The 94 GHz coherent transmitter-receiver has performed well as a radar at MICOM, but the failure of two mixers has prevented its being operated in the injection/phase lock mode. Both the mixer used for phase locking of the injection locking klystron and that used for phase locking the EIO have failed during the attempted checkout at MICOM. These mixers are being repaired and another attempt at coherent operation of the 94 GHz system will be made when the translator and signal processor are delivered.

Problems Encountered

New problems encountered are discussed in the above section.

Plans for Next Period

The frequency translator, data processor, and the 94 GHz mixers will be repaired and returned to MICOM. A major part of the final report will be written during the next reporting period.

Cost Information

The following charges have been incurred against the contract during the period May 1 - May 31, 1981.

Personal Services (PS)	$4,270.28
Materials and Supplies	204.08
Travel	.05
Overhead (@ 73% of PS)	3,117.30
Retirement (@11.11% of PS)	474.44
TOTAL	$8,066.15

The breakdown of personal services is as follows:

	Dollars	Approximate Man Hours
Principal Research Engineers	--	--
Senior Research Engineers	$2,321.90	120
Research Engineers	898.80	59
Assistant Research Engineers	951.72	74
Student Assistants	---	--
Technicians, Machinists	56.36	6
Clerical	41.50	6
TOTAL	$4,270.28	265

The current financial status of the contract is as follows:

	Budget as Proposed	Expended	Free Balance
Personal Services (PS)	$216,943.98	$197,995.04	$18,948.94
Materials and Supplies	248,151.34	296,684.39	(48,533.05)
Travel	2,698.00	2,905.72	(207.72)
Computer	400.00	0.00	400.00
Overhead	163,919.50	149,570.80	14,348.70
Retirement	20,829.18	16,411.30	4,417.88
AS PROPOSED	$652,942.00	$663,567.25	($10,625,25)

Based on present partial funding, the funding and equivalent man hours are sufficient to complete the task. Approximately 100% of the proposed task has been completed.

OUTPUT

VIDEO AMP

2ND DETECTOR AERTECH DOM 1048-1

750 MHz IF AMP MITEQ

BIAS

SCHOTTKY BARRIER MIXER HUGHES 47377H

ANTENNA TRG W832

LINEAR CIRCULAR SWITCHABLE POLARIZER TRG 883

SWITCHABLE LINEAR POLARIZER TRG W885

WR8-WR10 TRANSITION

2

WAVEGUIDE SWITCH TRG F120

E-H TUNER BAYTRON 3N-90

3

CIRCULATOR TRG F160

4

E-H TUNER BAYTRON 3N-90

BAYTRON 3N-22/40

1

ATTENUATOR TRG F520

WAVEMETER TRG F550

DETECTOR BAYTRON IN-5A

COUPLING CAVITY GA TECH

ATTENUATOR TRG F520

WR10-WR8 TRANSITION

BAYTRON 3N-22/40

94 GHz EIO VARIAN VKB 2443F1 (A)

COOLING AND POWER SUPPLY (A) GA TECH

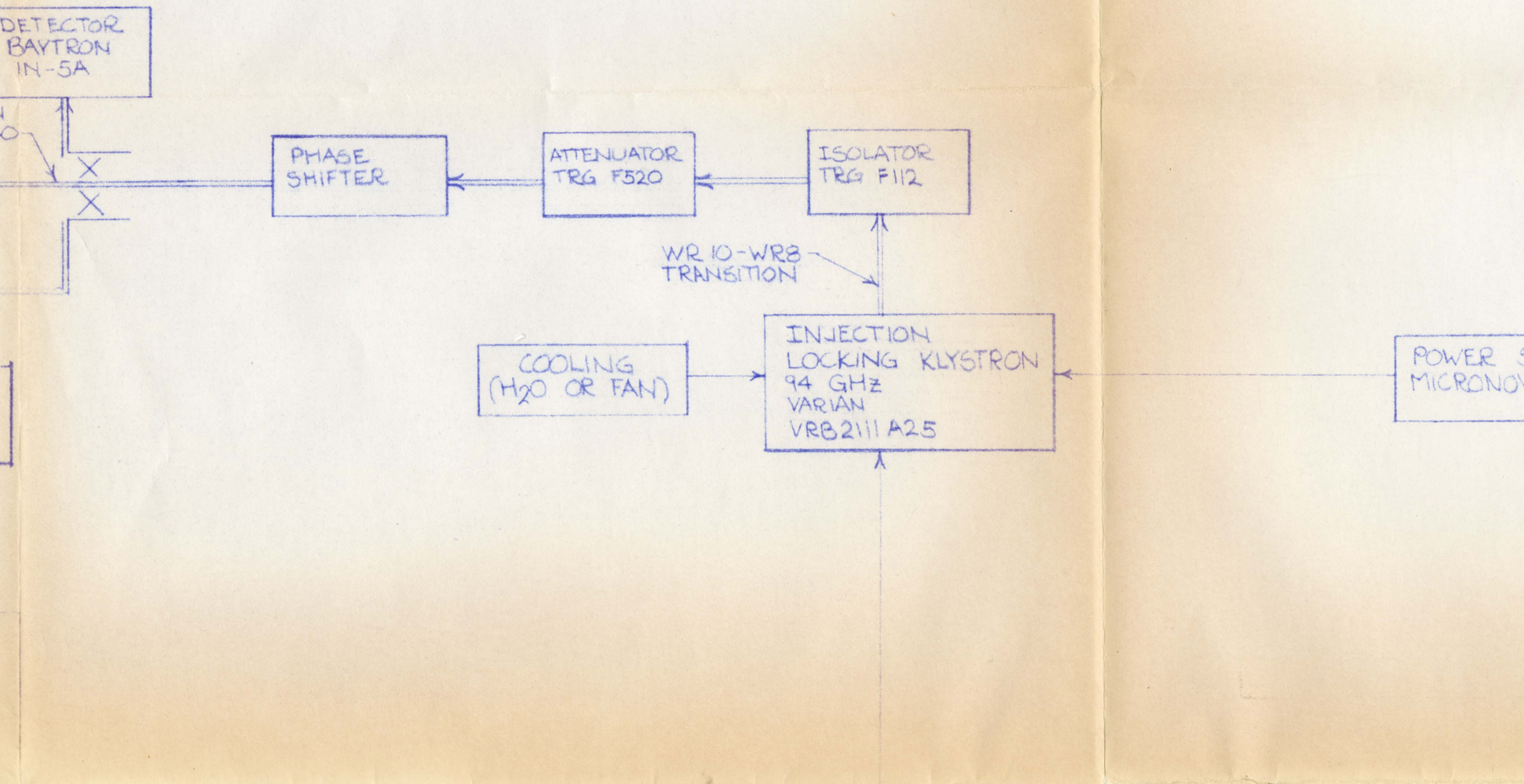
BAYTRON (A) 3N-22/20

COUPLING

4	3	2	1

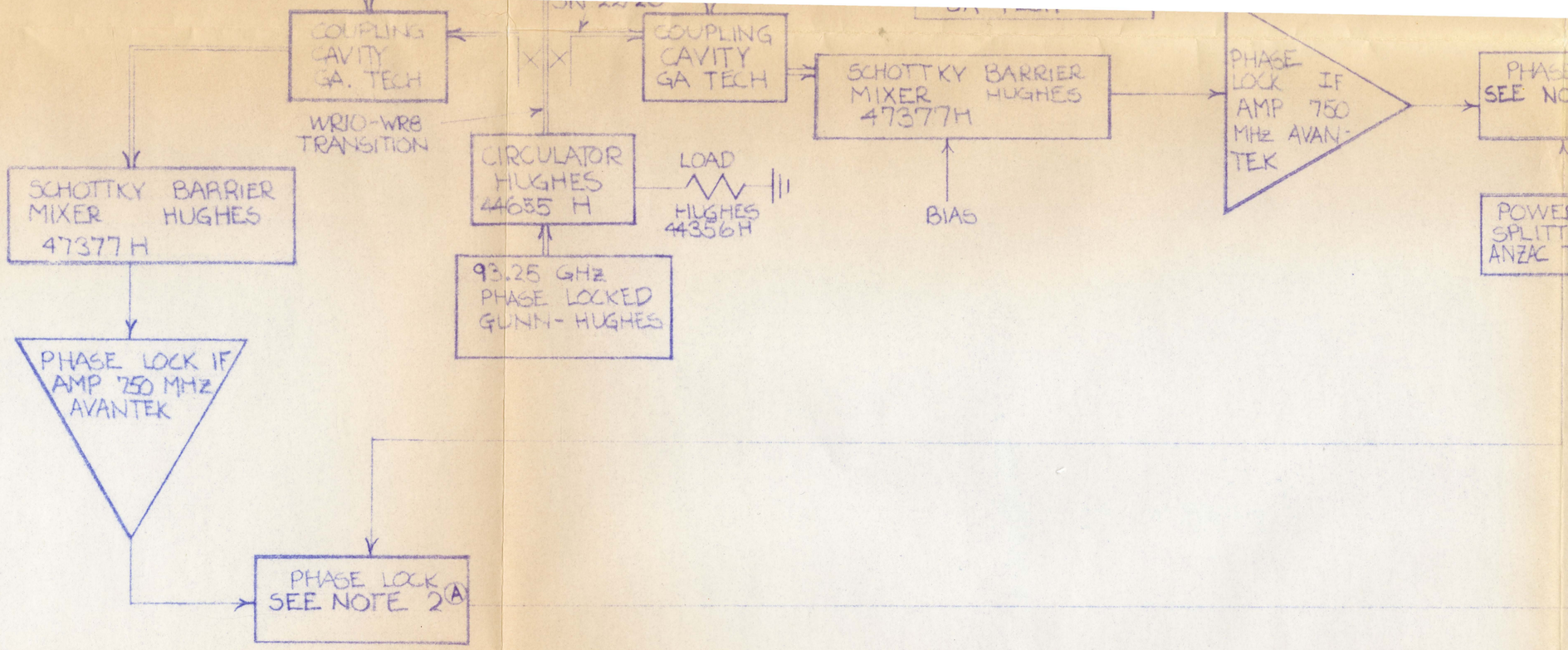
APPLICATION		
QTY REQD	NEXT ASSY	USED ON

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVED
A,B 5-7 C-6 C-5 C-5	(A)	NOTE 2 ADDED 93.25 WAS 13.25 3N-22/20 WAS 3N-22/40 2443F1 WAS 2443T1 POWER SUPPLY ADDED	5-16-79 a.r.	



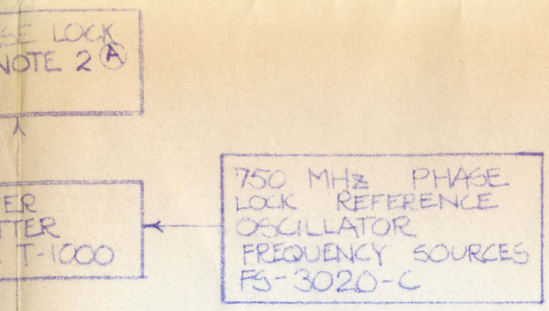
D

C



NOTES :

1. ═══ SYMBOL FOR WAVEGUIDE CONNECTION
2. PHASE LOCK BLOCK DIAGRAM IS SHOWN ON DWG. A 2166-006 (A)



B

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±

FRACTIONS ± ANGLES ± 0° 30'

MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES
EXCEPT AS NOTED
BREAK SHARP EDGES
AND CORNERS .010 MAX

FINISH

CONTRACT NO. A 2166

DWN	a.r.	5-9-79
ENGR		
CHK		
PROD		
APVD		
APVD		

GTEES
ENGINEERING EXPERIMENT STATION
OF THE
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

94 GHz BEAMRIDER SYSTEM
BLOCK DIAGRAM
FIGURE 1

A

SIZE	CODE IDENT NO.	DRAWING NO.	REV
D		A 2166-005	

SCALE NONE SHEET